EVALUATION OF THE P. K. YONGE INDIVIDUALIZED CHEMISTRY CURRICULUM FIELD TESTING PROGRAM IN FLORIDA

By

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To Sally, Sean and Laura

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Chairman: Vynce A. Hines
Major Department: Curriculum And Instruction

The problem investigated in this study was to determine the effectiveness of the P. K. Yonge Individualized Chemistry Program in selected public schools in Florida.

The study used a pre-test/post-test control group experimental design using classroom means from classes randomly selected as experimental and control. The study was carried out during a one-year period in twenty-one Florida schools. This school population consisted of 305 experimental students from 13 different classrooms and 282 control students from 8 different classrooms.

Four types of evaluation were used to determine the effectiveness of the experimental program. They were:

1. The American Chemical Society (ACS) High School Chemistry Test,
2. The Sequential Test of Educational Progress (STEP) Reading Test,
3. The All-School-Subject Attitude Test,
4. An experimenter-designed Student Questionnaire for formative analysis of the experimental program.

All these evaluations except the questionnaire were administered both prior to and after the study. Each test had two equivalent forms eliminating testing as a cause of invalidity.

The data analysis was done on an IBM-370 computer at the University of Florida using the Biomedical Statistical Programs. Data analysis using analysis of covariance at the 10 percent level of significance and analysis of variance of a factorial design at the 1 percent level of significance indicated the following results:

1. A significant difference was found between the experimental and control groups with respect to achievement in chemistry in favor of the control group. The major source of the difference was found to be in the high experimental group which had a considerable regression in achievement in chemistry.

2. A significant difference was found between the experimental and control groups with respect to attitude toward science. A net overall gain in attitude was seen in the experimental group.

3. No difference was found between the experimental and control groups with respect to reading ability.

4. There was no difference found between high and low achievers on the STEP Reading Test of either experimental or control groups with respect to achievement in chemistry.

5. Evaluation of the Student Questionnaire indicated a favorable attitude toward the Individualized Chemistry Program. Also, indications of problem areas in the program were pointed out.

CHAPTER I

INTRODUCTION

I. Study Orientation

During the past six years the science faculty at P. K. Yonge Laboratory School, University of Florida, have developed and field tested and taught an Individualized Chemistry Program in the public schools of Florida. This program is designed to give the student a better understanding of basic chemical concepts and relevant chemical applications through more individual contact with the teacher.

This study is designed to answer the following question: Can this program be taught effectively by chemistry teachers found in public schools in the state of Florida?

II. Rationale

For years many teachers have treated students as if they learned at the same rate. Consider the average science class: The teacher stands in front of a class of students lecturing for 50 minutes. A few bold students ask questions, the rest remain silent listening or copying material from the board. On another day in the same class, the students perform the same experiment and are required to finish it by the end of the period. This is the way many science courses are taught in high schools in America and abroad. What happens to the student who does not understand the material presented in the lecture? What about the slow or reflective student who doesn't quite finish the experiment in the required time?

If we look at these problems from the student's point of view, the student is forced to "keep up the pace". The student who cannot learn as rapidly as the average student in the class is considered a "failure". We punish a student for not learning as rapidly as we think he should learn (1). Educationally we should recognize individual differences. Self concept, the way we think of ourselves, is very important to a student in high school. Piaget (2) said: "The goal of education is not to increase the amount of knowledge but to create possibilities for a child to invent and discover, to create men who are capable of doing new things."

Science education for many years has "turned off" many students in the fields of science (3). The "turned off" appear to fall into two groups: (a) some students do not learn as rapidly as others--the teacher presents material faster than the students can comprehend and (b) some students become bored (the bright ones) since the material is presented in a dry and uninteresting fashion. Individualizing instruction may be the solution for both groups. This is not a new concept; to individualize or not to individualize has been discussed by many over the past years (4-6).

III. Definition Of Terms

Attitude. A positive or negative reaction of feeling, believing or thinking toward or about ideas, people, objects or organizations.

Self-Concept. How one perceives oneself

Individualized Instruction. Individualized Instruction means many things to many people. For this study, the definition of Individualized Instruction is not:

Study packets
Audio-tutorial programs
Self-pacing
Systems approach
Instructional or behavioral objectives

But rather, Individualized Instruction is:

1. Identifying the key concepts to be studied either by the student or jointly by the instructor and student.
2. Knowing the student well enough to determine his cognitive style (i.e., how he learns) and his affective style (i.e., his attitude toward learning).
3. Planning with the student, those activities which will cause him to achieve the objectives of the course or program.
4. Evaluating the student in terms of his success or ability to meet the stated objectives rather than some mythical set of group norms.
5. The teacher is a resource person--not a lecturer.
6. The student pursues his study at his own rate using any form of media available.
7. The student performs open-ended laboratory work.

IV. Historical Context

Individualized programs have been with us for many years and each program has had its own meaning of individualizing. Aristotle individualized by involving his small group of students in what they were to learn. The Parker Schools in Quincy, Massachusetts, and the Cook County Normal School in Chicago, were centered around the child and his interests during the 1880's and 1890's. In the early 20th Century, John Dewey said to bring education to the child, not the child to education. To individualize in those days meant to try to meet the educational needs of the students. But these needs were most often defined by people who had little or no understanding of the many needs associated with the various developmental levels and cognitive styles of students. Thus programs that were designed met the needs of only a few, leaving the rest to fair for themselves. From the success or lack of success

of these programs, educators began to learn about the varied educational needs found in each classroom.

Many plans were designed to "individualize" the curriculum and break the academic lockstep such as project methods, homogeneous groupings, ability groupings, and integrated programs. Audio-visual aids, libraries, guidance departments, lunches, recreation, transportation and work experience programs were added to school systems to better take care of student needs. Extensive testing programs were incorporated in school systems to aid the process of assessing individual abilities and setting standards of school achievement for various age and grade groups.

But all these attempts at individualization fell short of complete success. The totally individualized classroom requires much more support and knowledge than is available even today. We still are groping for a basic understanding of student learning behaviors and the techniques for determining what the behaviors are and what they mean. Many programs have recently come out using a multi-media approach toward meeting the varied needs of students. These programs, along with team teaching, open classrooms and learning modules, are a step in the right direction toward a truly individualized program.

An example of an attempt at individualization is the Individualized Chemistry Program, a self-paced, individualized approach to teaching high school chemistry. This program, developed at P. K. Yonge Laboratory School, University of Florida, utilizes many of the approaches discussed above along with some new techniques to try to meet the educational as well as the practical needs of a student wishing to learn about chemistry. This program was developed and evaluated in the classroom with students providing formative evaluation to the materials.

The first major step in the development of an individualized program in chemistry at P. K. Yonge Laboratory School occurred during the summer, 1969. Six graduate students involved in a clinical teaching experience at P. K. Yonge, designed and implemented an individualized program in chemistry. Students from the Gainesville area volunteered for the program. The teachers wanted to put into practice the ideas that they had read relative to individualizing instruction. They identified the concepts to be taught, planned the usage of several strategies for instruction, procured a wide variety of materials, and developed an elaborate procedure for evaluating student progress.

During the clinical teaching experience, video tapes were made of the teachers and students. The actions of the teachers and students were evaluated using four systematic observation instruments: Teacher Practice Observation Record (TPOR), Reciprocal Categories System (RCS), Florida Taxonomy of Cognitive Behavior (FTCB), and Taxonomy of Image Provoking Behavior (TIPB). Some of the resulting research findings were used as a basis for the design of the P. K. Yonge Individualized Chemistry Program. For example, it was found that problem sessions, where the teacher went over either homework or class problems, elicited a rather low level cognitive behavior on the part of the students. Based on this research finding, formal homework and problem sessions were not included as a strategy in the Individualized Chemistry Program. Instead, students in the Individualized Chemistry Program are encouraged to work the problems assigned, check the answers themselves and then see the teacher about those problems which they did not understand. The instruments also indicated that straight lecture produced a rather low level of cognitive behavior. Therefore, the formal lecture was de-

emphasized in the chemistry program. It was replaced with individual and small group sessions with an occasional 'mini' lecture when a large number of students wanted to know something about the same topic.

Many ideas and strategies were tested during the clinical teaching experience such as team teaching and team planning, extensive use of media, alternative laboratory experiences for a given concept, use of oral quizzes, student self evaluation and project work (7).

This study provided the catalyst for the development of the Individualized Chemistry Program at P. K. Yonge.

V. The P. K. Yonge Individualized Chemistry Program

Most schools have a set of general goals which represents the philosophy of the school and provides the framework for the program of instruction. The chemistry program to be described is based upon and consistent with the following general goals for students at P. K. Yonge:

1. That each student develop increasingly positive perceptions of himself.

2. That each student become an effective life-long learner.

3. That each student accept increasing responsibility for his own behavior and learning.

4. That each student develop those skills and attitudes necessary for effective group living and democratic interaction.

5. That each student learn to adapt to change and positively effect change.

6. That each student find real meaning for his life.

These goals were used as guidelines in developing the program.

In order to develop and maintain successful programs of science there must exist a clear relationship among the stated goals of a school,

the instructional objectives of a given program, and the activities utilized to implement that program. This idea was kept in mind as this particular program was developed.

The program itself is patterned after a model of instruction developed at P. K. Yonge Laboratory School which is used in science courses at the school. The model basically illustrates that in an individualized program there are ideas with which all students should come in contact, there are ideas that are "nice to know", and there are skills necessary for the understanding of the basic ideas (Figure 1).

Once the model was established, the next step was to organize the content. Rather than scrapping the existing chemistry program, those parts that were successful were pulled from it. The program was organized into one basic unit--Introduction to Chemistry and four optional units--Chemical Reactions and Energetics, Atom and Molecular Theory, Biochemistry and Nuclear Chemistry (Figure 2).

Each of these units were further divided into a basic instructional unit called a "Guide Sheet" (Figure 3). Each guide sheet consisted of a series of questions which were designed to help the student clarify and understand the concept or concepts related to that guide sheet. In addition to the questions, there were problems to work and laboratory experiments to be performed. Each guide sheet was developed around a general instructional objective while each lab was developed on the basis of its ability to produce a certain behavior. A behavioral objective was stated for each lab. An all-out effort was made to correlate the problems, questions and laboratories so that the student would begin to formulate and acquire the concepts involved. The questions were worded in such a manner that the student had to use more than one

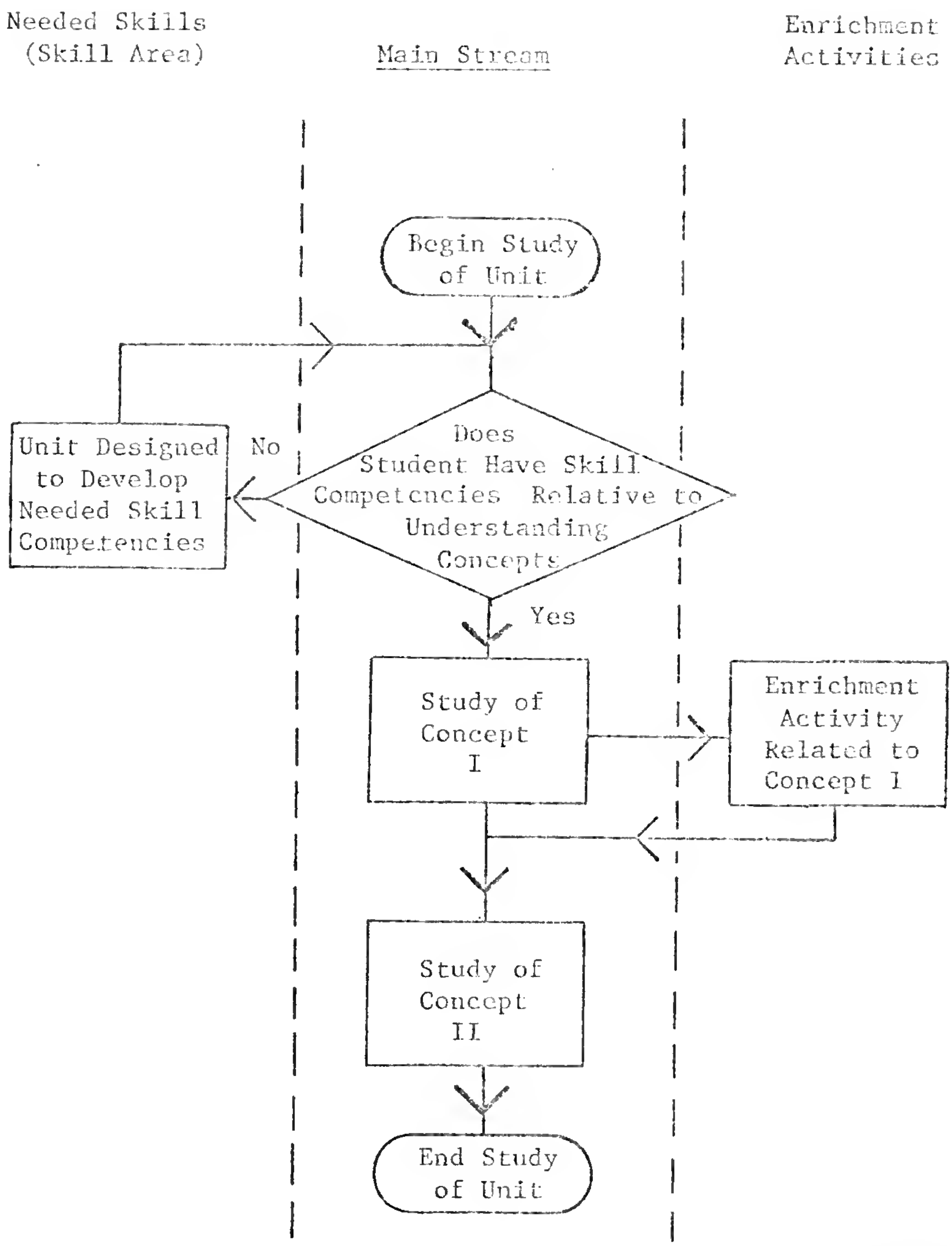

Figure 1: Stylized Model for Individualizing Instruction

I. UNIT I: INTRODUCTION TO CHEMISTRY

Guide Sheet 1: Man and Science
Guide Sheet 2: Sand and Mortar of Chemistry
Guide Sheet 3: Mendeleev's Brainchild
Guide Sheet 4: The Devious Mole
Guide Sheet 5: A Matter of Phases
Guide Sheet 6: Nuclear Chemistry
Guide Sheet 7: Biochemistry

II. UNIT II: CHEMICAL REACTIONS AND ENERGETICS

Guide Sheet 1: Energy Effects and Rates of Reactions
Guide Sheet 2: Equilibrium in Chemical Reactions
Guide Sheet 3: Acids, Bases and Oxidation-reduction Reactions

III. UNIT III: ATOMIC AND MOLECULAR THEORY

Guide Sheet 1: The Atom
Guide Sheet 2: Quanta and Electron Orbitals
Guide Sheet 3: Bonding

IV. UNIT IV: BIOCHEMISTRY

Guide Sheet 1: Carbon and His Buddies
Guide Sheet 2: Sugars and Carbohydrates
Guide Sheet 3: Proteins and Enzymes
Guide Sheet 4: RNA-DNA and Life

V. UNIT V: NUCLEAR CHEMISTRY

Guide Sheet 1: Properties of the Nucleus
Guide Sheet 2: Natural Radioactivity and Fission
Guide Sheet 3: Fusion and Stellar Element Formation

Figure 2: Outline of Individualized Chemistry Program

UNIT I: INTRODUCTION TO CHEMISTRY

Guide Sheet 1: Man & Science

Objective:

You are to develop an awareness of the role of the scientist in society.

GUIDE QUESTIONS:

1. Without consulting any source of information, list what you think are some characteristics of a scientist.

2. Do some reading about alchemy and the alchemists and answer the following questions:

   A. What was alchemy?
   B. What was the alchemist trying to prove?
   C. What influence did alchemy have on modern science?

3. Are scientists today any different than they were 100 or 200 years ago? Explain.

4. Are scientists today more 'in tune' with the world than they were in previous times? Explain.

5. Can man be a scientist and be responsive to the society at the same time? In what ways?

6. What is the difference between science and technology?

7. What are some of the problems supposedly created by technology?

8. Who has the responsibility for finding solutions to the major technological problems of today?

9. The following is a list of chemical names used in the past. Write the modern name for each one listed.

   A. Acid of Salt
   B. Phlogiston
   C. Dephlogisticated Acid of Salt
   D. Aqua Fortis
   E. Aqua Regia
   F. Oil of Vitriol
   G. Cinnabar
   H. Mercurial Sublimate

PROBLEMS:	LABS:	REFERENCES:
No problems assigned.	# 1 & 2	General chemistry books Recent periodicals

Figure 3: Sample Guide Sheet

source of information. Students need to use more than a single source or text in order to become aware of different ways of expressing ideas and to learn not to rely on any one source as prividing the "whole truth". The program is highly laboratory-oriented. There are 36 laboratories which are part of the main stream and 10 option or enrichment laboratories (Figure 4).

A contract for time was developed and was used by the students (8). Students want freedom but at the same time they need some structure. The contract for time was a compromise (Figure 5). It was found that during the pilot study of this program students tended to put off their chemistry in order to do more pressing work in other subjects. This caused many students to lag behind their potential work rate. It was decided that many students, probably because of the nature of our educational system, were not ready to be totally independent and actually requested that some means of pressure be exerted to help them keep up in the course. The contract idea was thought to be the most fair and realistic solution to the problem. When the contract comes due for the student, a one-week grace period remains. By the end of the grace period, the student must take the quiz or evaluation designed for that guide sheet or be penalized. If minimum expectations are not attained for the guide sheet, the student is recycled with a specific study plan aimed at helping him understand the ideas which were not clear. Each student should attain some basic level of understanding of each of the concepts presented before proceeding. Hopefully, the student will arrive at the end of the program with concepts that are relatively clear and distinct in his mind.

Before the student can take the quiz associated with the Guide

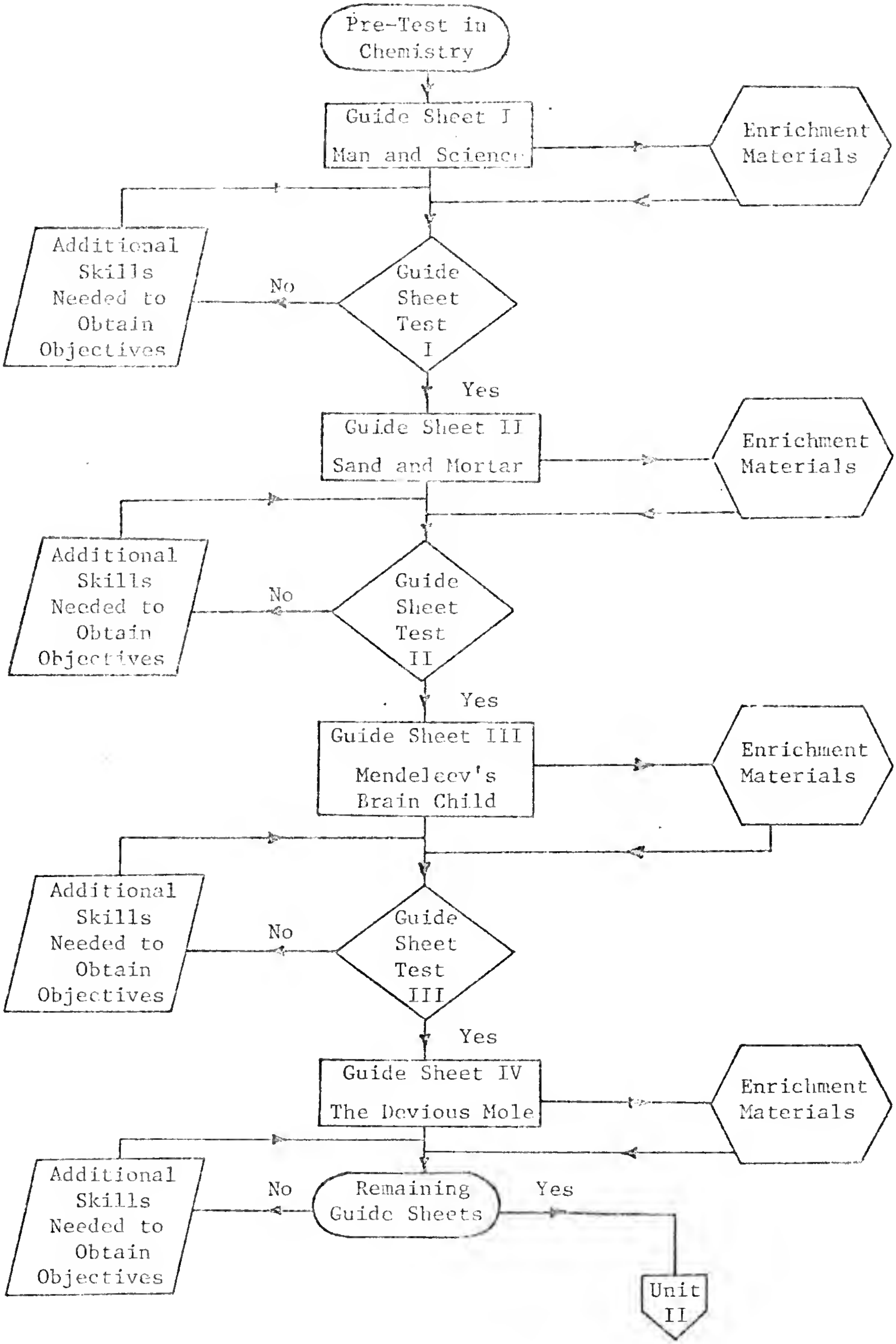

Figure 4: Flow Diagram of Unit I

INDIVIDUALIZED CHEMISTRY CONTRACT

NAME: ______________________________ DATE: __________

UNIT NUMBER ________________

GUIDE SHEET NUMBER ________________

I ______________________________ WILL ENDEAVOR TO COMPLETE THE ABOVE MENTIONED GUIDE SHEET BY ________________. I UNDERSTAND THAT IF I DO NOT COMPLETE THE MATERIAL BY THE INDICATED DATE, I WILL BE GIVEN A ONE WEEK GRACE PERIOD IN WHICH TO COMPLETE THE AFOREMENTIONED MATERIAL. ON OR BEFORE THE END OF THE GRACE PERIOD I WILL TAKE THE GUIDE SHEET TEST COVERING THE CONCEPTS IN THE ABOVE MENTIONED GUIDE SHEET. A TWENTY POINT BONUS WILL BE AWARDED IF WORK IS COMPLETED BEFORE THE DEADLINE DATE. THERE WILL BE A PENALTY OF FIVE POINTS FOR EACH DAY I EXTEND BEYOND GRACE PERIOD DEADLINE.

SIGNED: ________________________

WITNESSED: ________________________ CHEMISTRY INSTRUCTOR

DATE: ________________________

CC: TO THE CHEMISTRY INSTRUCTOR

Figure 5: Student Contract

Sheet, he must have all of this material checked and reviewed by the teacher. Specifically, the teacher checks the guide questions and the labs; the student checks his own problems noting the ones he missed. The teacher and student sit down and go over all of this together clarifying those points that are unclear. At this point, the student takes the quiz.

The system of evaluation consisted of a bank of quiz questions, each of which was on a "key-sort" card. The student is given the deck and he selects however many questions as he needs to obtain 100 points. Each question has been labelled according to Bloom's Taxonomy of Cognition; each level given a point weight: Level 1 worth 5 points, Level 2 worth 7 points, and so forth.

It should be interjected at this point that if one is committed to a personalized, individualized program, class standards no longer are valid. Therefore, it does not make any difference if one student does five questions and another does 10 or that they both do not do the same questions. What is important is that teachers try to provide instructional settings that are nonthreatening and that tend to enhance the individual's concept. The teacher should try to have students see the quizzes as a small part of the total program, a means of helping them and the teacher to know if they can apply what they have learned.

Unit I and II contain a large number of one level and two level questions but also contain questions from the three, four, five and six levels. In Unit III, the number of one and two level questions is reduced and the number of three level questions is increased; the same procedure is followed in Unit IV with the over-all level of questions being higher than Unit III.

Students entering chemistry can be likened to students entering a foreign language class. Both groups of students have a basic vocabulary problem. Until the vocabulary and basic structure of both chemistry and a foreign language are mastered, no advanced understanding or study can take place. Therefore, there is a need to learn the basic facts, terminology and vocabulary in order to communicate. Once this has been established the student can go on to build and acquire concepts and ideas. In terms of Bloom's Taxonomy, chemistry is seen at the application level. Attempts have been made to design the cognitive part of the program in such a way that the student will be operating cognitively at that level at the end of the program.

Record keeping for this type of program is important and could be very time consuming. One of the teachers testing the program suggested using a card for each student. The student keeps track of what he has done. This helps to keep him aware of where he is in the program (Figure 6). Another teacher developed this idea into a student folder. A file folder is set up for each student. The student keeps the folder up dated and is responsible for keeping track of his progress. The folder consists of the following to be used for each Guide Sheet: 1) Contract (Figure 5), 2) Student Inventory Sheet (Figure 7), 3) Total Evaluation Form (Figure 8), and 4) Individualized Chemistry Progress Report (Figure 9). Students were found to keep very accurate records. At the end of each marking period, the student records his progress for that period and the evaluation is sent home to his parents (Figure 10). No longer are statements such as these heard: "What grade am I getting this time" or "I don't understand why I got a C".

At this time formal affective objectives have not been stated other

COURSE RECORD CARD

CHEMISTRY

________ Class Period　　　　Core Section ______

NAME ______________________　　UNIT ______　　TOTAL UNIT POINTS ______

UNIT GRADE ______

		Date Completed
GS I:	QUIZ GRADE _____	
Problems:	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	______
Guide Questions:	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	______
Labs:	__ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __	
GS II:	QUIZ GRADE _____	
Problems:	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	______
Guide Questions:	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	______
Labs:	__ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __	
GS III:	QUIZ GRADE _____	
Problems:	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	______
Guide Questions:	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	______
Labs:	__ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __	
GS IV:	QUIZ GRADE _____	
Problems:	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	______
Guide Questions:	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	______
Labs:	__ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __	

Figure 6: Course Record Card

STUDENT INVENTORY SHEET

NAME ______________________________ UNIT __________ GUIDE SHEET __________

PERIOD ______________________________ CONTRACT DEAD-LINE DATE __________

Guide Questions		Problems		Laboratory		Extra Guide Questions		Enrichment Material		Skills	
No.	Date Completed	No.	Date Completed	No.	Date Completed	No.	Date Completed	No.	Date Completed	No.	Date Completed

Figure 7: Student Inventory

TOTAL EVALUATION

Name ________________________ Unit ________ Guide Sheet ______

Contract Dead-Line Date ________

	Points	Maximum Points
Guide Questions	________	10
Problems	________	10
Laboratory	________	20/lab.
Extra Guide Questions	________	
Enrichment Materials	________	
Skills	________	
Guide Sheet Quiz	________	
Total	________	

Final Grade ____________________

Figure 8: Total Evaluation

INDIVIDUALIZED CHEMISTRY PROGRESS REPORT

Name ______________________ Period ______________________

Grade ______________________ Instructor ______________________

	Letter Grade
Unit I: Introduction to Chemistry	
Guide Sheet 1: Man and Science	________
Guide Sheet 2: Sand and Mortar of Chemistry	________
Guide Sheet 3: Mendeleev's Brainchild	________
Guide Sheet 4: The Devious Mole	________
Guide Sheet 5: A Matter of Phases	________
Guide Sheet 6: Nuclear Chemistry	________
Guide Sheet 7: Biochemistry	________
Unit Grade	________
Unit II: Chemical Reactions and Energetics	
Guide Sheet 1: Energy Effects and Rates of Reactions	________
Guide Sheet 2: Equilibrium in Chemical Reactions	________
Guide Sheet 3: Acids, Bases and Oxidation — Reduction Reactions	________
Unit Grade	________
Unit III: Atomic and Molecular Theory	
Guide Sheet 1: The Atom	________
Guide Sheet 2: Quanta and Electron Orbitals	________
Guide Sheet 3: Bonding	________
Unit Grade	________
Unit IV: Biochemistry	
Guide Sheet 1: Carbon and His Buddies	________
Guide Sheet 2: Sugars and Carbohydrates	________
Guide Sheet 3: Proteins and Enzymes	________
Guide Sheet 4: RNA--DNA and Life	________
Unit Grade	________
Unit V: Nuclear Chemistry	
Guide Sheet 1: Properties of the Nucleus	________
Guide Sheet 2: Natural Radioactivity and Fission	________
Guide Sheet 3: Fusion and Stellar Element Formation	________
Unit Grade	________

Figure 9: Progress Report

Date __________ P. K. Yonge Laboratory School

INDIVIDUALIZED CHEMISTRY PROGRESS REPORT

Name ______________________________ Grade __________

Advisory Group Leader: Chemistry Teacher:

______________________________ Mr. P. A. Becht

This year the Chemistry Class is involved in continuing a tested concept of teaching - individualization. In other words, the student works at his own rate using the teacher as a resource person. The student is given "Guide Sheets" to assist him in obtaining his goal - the use and understanding of the basic concepts in chemistry.

The course is designed in five units: 1. Introduction to Chemistry, 2. Chemical Reactions, 3. Atomic Theory, 4. Biochemistry, and 5. Nuclear Chemistry. These five units are broken into a series of guide sheets that assign specific tasks to the students. As a student completes the tasks on the guide sheet, he becomes qualified to take an exam covering the material on the guide sheet. The student is given a specified number of points on completion of the guide sheet and, when all the guide sheets for a unit have been completed, the student will receive a letter grade for the unit. No letter grade will be given to a student until the unit is completed. The reason this procedure was adopted was to allow students to work at their own pace toward completion of the guide sheets and the units. This means that most students will be at different stages in their course work and there will be no way to fairly evaluate the student with respect to his progress and the rest of the class. Therefore, no letter grade will appear on the report card until a unit is completed. Only "S", "U" or "I" will be given indicating satisfactory, unsatisfactory, or incomplete progress in the course.

In order for the student to receive credit in the course, he must satisfactorily complete Unit I, and any two other units or an equivalent two units as decided by the student and teacher.

So that you, the parent, may be aware of your son's/daughter's progress, a dittoed sheet indicating units completed will be sent home at the end of each grading period.

- -

Figure 10: Grade Report

	COMPLETED
I. Unit I: Introduction to Chemistry	
a. Guide Sheet 1: Man and Science	______
b. Guide Sheet 2: Sand and Mortar of Chemistry	______
c. Guide Sheet 3: Mendeleev's Brainchild	______
d. Guide Sheet 4: The Devious Mole	______
e. Guide Sheet 5: A Matter of Phases	______
f. Guide Sheet 6: Nuclear Chemistry	______
g. Guide Sheet 7: Biochemistry	______
II. Unit II: Chemical Reactions and Energetics	
a. Guide Sheet 1: Energy Effects and Rates of Reactions	______
b. Guide Sheet 2: Equilibrium in Chemical Reactions	______
c. Guide Sheet 3: Acids, Bases and Oxidation-Reduction Reactions	______
III. Unit III: Atomic and Molecular Theory	
a. Guide Sheet 1: The Atom	______
b. Guide Sheet 2: Quanta and Electron Orbitals	______
c. Guide Sheet 3: Bonding	______
IV. Unit IV: Biochemistry	
a. Guide Sheet 1: Carbon and His Buddies	______
b. Guide Sheet 2: Sugars and Carbohydrates	______
c. Guide Sheet 3: Proteins and Enzymes	______
d. Guide Sheet 4: RNA-DNA and Life	______
V. Unit V: Nuclear Chemistry	
a. Guide Sheet 1: Properties of the Nucleus	______
b. Guide Sheet 2: Natural Radioactivity and Fission	______
c. Guide Sheet 3: Fusion and Stellar Element Formation	______

Figure 10 (Cont'd.)

than in the general objectives, but there are many informal ways for developing positive attitudes toward science, learning in general, and the importance of worthiness of each individual. This is demonstrated by the responsibilities given to the student in this type of program. First, recognizing that each person is unique and his patterns of learning are different, he is encouraged to proceed with his study of chemistry at the rate commensurate with his background and former knowledge. The student keeps his own records and has some choice over the kinds of quiz questions which he takes. The student is encouraged to give feedback in terms of which laboratories helped the most and which helped the least in understanding or learning a particular concept or idea. The student is given the freedom to decide each day how he is to use his time. Does he do a lab, work problems, ask questions or do nothing?

This type of program also helps to keep the student thinking positively about science and school in general. He does not get uptight nor do the teachers if he is absent because of sickness, sports, or other student activities. The student knows what is expected of him and can proceed accordingly. No longer does the student ask: "What have I missed?" or "What do I have to make up?" or "When can I come in to see you about what I missed in class?".

Personal contact with the students in the class increases. Most of the teacher's time in class is spent in a one-to-one ratio or small group interaction with students. The teacher may go over the same idea many times but goes over it when the student is ready rather than when the teacher thought all students were ready.

These factors formulate the basis of the Individualized Chemistry Program at P. K. Yonge Laboratory School. The program will constantly

be undergoing change and modification. If educators are to provide the best education for students, then any program which is to have survival value must be of a dynamic nature.

VI. Statement Of The Problem

The problem in this study is to determine the effectiveness of the P. K. Yonge Individualized Chemistry Program in selected public high schools in Florida when taught by the chemistry teachers found in these schools.

VII. Pilot Project And Study

In the fall of 1969, it was decided to begin to design and implement an individualized program in chemistry as part of the science program at P. K. Yonge. Dr. D. P. Altieri and the writer began designing by night and teaching by day. It would have been better to wait a year and do some careful planning, but the frustration level with the teaching of traditional chemistry was too high to combat. Three classes of approximately 30 students each were involved in the study. Since the course was being developed as the year progressed, the students were encouraged to take part in the development. A graduate student in chemistry education became interested in the project. She wanted to become involved. The major need at this point was feedback from the students relative to the effectiveness of the program. This student designed and administered a questionnaire to the students in the program and tallied the results. This became the first formative evaluation and it was used to modify and strengthen the program. A modified

form of this questionnaire was used in subsequent field testing of the Individualized Chemistry Program (Figure 11). Also a closer contact with students provided the opportunity to discuss individual problems about the course with the student. This formative evaluation greatly assisted the development of the program. As the school year neared its end, many students found themselves behind in their work. Since individualization allows one to work at his own rate with respect to certain guidelines, the students found themselves behind because there was no pressure to do certain assignments by a certain time as in other courses. Many students put off chemistry until other pressing assignments were out of the way. The contract idea developed out of this problem.

Another advantage of the pilot study was the assistance given by the students toward the development of meaningful laboratory experiences. From students' responses, experiments were eliminated that were only exercises and replaced with useful and practical experiments that related more directly to the topic under study.

At the beginning and the end of the year, the questionnaire and the American Chemical Society (ACS) Chemistry Exam was administered.

Many students did not complete the course during the year because we had not used the contract idea and there was no immediate pressure to complete any given amount of work in a given time. One of the strongest comments on both questionnaires was the need to have some pressure to force the student to work.

Major emphasis of the project during the first year included identifying content, developing a management system which included a system for student evaluation, and coordinating laboratory activities.

Based on the feedback from the student questionnaires, the program

INDIVIDUALIZED CHEMISTRY QUESTIONNAIRE

PART A

Answer Part A only on the answer sheet provided. For each of the following questions indicate your answer on the answer sheet corresponding to the question number being answered. Use the following scale to code the answer sheet.

1 = Strongly Agree
2 = Agree
3 = Don't Know
4 = Disagree
5 = Strongly Disagree

This is not a timed test. Take your time and when finished turn in both the questionnaire and the answer sheet to your teacher.

1. Performing experiments in class helps me understand the chemical concepts I have been studying.
2. The results of my experiments make sense.
3. I have enough mathematical background to do the problems assigned.
4. I see a new value in studying chemistry I did not see before.
5. The pressure of other classes (having certain assignments ready at certain times) cause me to "put off" doing chemistry.
6. I am satisfied with my progress in this class.
7. I plan the work I expect to cover in a week or contracted period of time.
8. I feel that I can ask questions at any time.
9. I ask questions when I don't understand.
10. The tests are fair.
11. I look back every week (or some other period of time) and evaluate my progress.
12. I think the tests really measure what I know.
13. Answering the questions on the guide sheets really helps me.
14. I chose to take this course.

Figure 11: Student Questionnaire

15. "Individualized Study" is the best way to study chemistry.

16. I am able to see a direction in what I am studying in Chemistry.

17. I understand and can explain the concepts I have studied in Chemistry.

18. As a result of this course, I now know how some of the great discoveries in science were made.

19. As a result of this course, I plan to major in science or math in college.

20. I feel confident that I can handle this subject on an "individual study" basis.

21. I enjoy discussing this class at home.

22. I feel free to discuss chemistry (problems, experiments, etc.) with my classmates.

23. I see relationships between what I am learning in Chemistry and what I have learned in other science courses.

24. I am able to read and understand the textbooks I am using.

25. From what I have experienced in science, I think a scientist can be creative.

26. I find science exciting.

PART B

Please answer the following in the space provided.

1. What unit and guide sheet are you working on at this time?

2. If other classes pressure you to put off chemistry, what can be done about this problem?

Figure 11 (Cont'd.)

3. How do you plan your work week for chemistry?

4. Has this course been helpful to you? In what way?

5. What did you expect from this course when you signed up for it? Are you getting what you expected?

6. What do you find most rewarding in this class?

7. What do you find least rewarding in this class?

8. How would you revise the set-up of this course to make it more rewarding for you?

9. Besides your tests and lab equipment, what other "aids" available in your classroom have you used?

10. Please make any additional comments or suggestions which would make the class a better "learning situation".

Figure 11 (Cont'd.)

was modified and updated during the summer of 1970. Because of growing interest in individualizing instruction, it was decided to begin a limited field testing operation.

The following year a small grant was received from the Florida Educational Research and Development Council to field test the program in the public school system of Florida. A research design was developed and the program was implemented in seven schools in the state of Florida: Buchholz High School, Gainesville; Gainesville High School, Gainesville; P. K. Yonge Laboratory School, Gainesville; Cedar Key High School, Cedar Key; Newberry High School, Newberry; Lakeland Senior High School, Lakeland; Paxton High School, Paxton. Because of limited funding, all the schools participated on a voluntary basis only. The schools varied in size from a small rural type high school with only seven students in the chemistry class to a large city high school with eight classes of 30 students in each class. Students in these schools represented a cross-section of different types of students in Florida schools and therefore were a heterogeneous population. The student population of the field study, including experimental and control students was nearly 500.

Experimental and control groups were assigned in accordance with the Non-equivalent Control Group, Design No. 10 of the Campbell and Stanley design series (28).

$$\begin{array}{ccc} O_1 & X & O_2 \\ \hline O_3 & & O_4 \end{array}$$

This design has no control for external validity, but controls for all sources of internal invalidity except regression effects and the interaction of selection and maturation.

Selection of participating schools was necessarily limited to those few who were willing to cooperate on short notice, and with a minimum of control from the researchers. As a result, much valuable data was lost due to failure of some participating schools to furnish both pre-test and post-test scores from their students. The failure of control group data to be significantly large rendered the calculation of 't' tests impracticable in several instances.

Instruments used were the ACS Chemistry Test, the Sequential Test of Educational Progress (STEP) Reading Test, the All-School-Subjects Attitude Scale, and locally prepared questionnaires for both teachers and students.

Hypothesis expressed in NULL FORM were:

1. There will be no significant difference between the experimental and control groups with respect to achievement in chemistry.

2. Experimental and control groups will show no significant changes in attitudes towards science (and self).

3. There will be no significant difference between experimental and control groups with respect to reading ability.

4. There will be no significant difference in achievement in chemistry between slow and fast readers in the experimental and control groups.

Evaluation techniques planned included use of the 't' tests for population control, analysis of variance to control for differences between experimental and control groups in terms of the dependent variables, analysis of variance to test for differences in attitude and reading ability, and use of a correlation matrix to study the relationship between achievement and the variables of attitude and reading ability.

Results of the analysis of data were not considered reportable because of the lack of sufficient matched data from the field schools. Unfortunately, many of the schools participating in the study had racial problems during the last six weeks of school and many of the teachers were not able to administer the post-tests to the students. With only 10 percent of the post-test data returned, statistical results would be invalid.

There was one bright spot that kept the study from becoming a complete failure, most of the student and teacher questionnaires were returned giving adequate formative data indicating need for program improvement.

Teachers and students were very favorable towards the course and made many suggestions to help improve both the technique and subject matter of the course. This formative evaluation and suggested improvements helped to make the course more meaningful to the student and more helpful to the teacher. Feedback from the classroom teacher is necessary and important in curriculum development.

The field testing, which this dissertation describes, was designed taking into account the information gained from the testing and the formative evaluations in the pilot study. These evaluations indicated to the researcher that the program was working and producing meaningful results. Hypothesis were developed and the study undertaken in the format discussed under the research design section.

CHAPTER II
REVIEW OF THE LITERATURE

For centuries teachers have been using mass instruction methods based on a situation in the middle ages before the invention of printing when the teacher-lecturer had the only book on the subject at his school or university.

Today a complete restructuring of the basic teacher-pupil relationship is needed to take advantage of the many new materials and methods available. This breakthrough is the individualizing of education.

Individualizing education had its beginnings in the 1860's when the "object method" of teaching and methods of nature study were introduced according to the pattern of the Swiss educator Johann Heinrich Pestalozzi. Edward A. Sheldon and the normal school at Oswego, N.Y. were influential in spreading Pestalozzian ideas in America.

Another influential leader in making the child and his interests the center of the educative process was Francis W. Parker in his schools at Quincy, Mass., and the Cook County normal school in Chicago in the 1880's and 1890's. Further stimulus to modern educational methods came from John Dewey through his experimental school at the University of Chicago in the late 19th and early 20th centuries and through his writings on educational theory and practice.

The development of objective tests and measurements of scholastic achievement aided the process of diagnosing individual abilities and

helped set standards of school achievement for the various age and grade groups. These objective tests helped educators to begin to look at the individual needs and abilities of students in order to better understand how to more personalize education (8,9).

Individualized instruction will have to take into account a transition from "How it's done now", to "What will be done tomorrow". We can use more than the printed page to break away from the lock-step, every-one-do-the-same-thing-at-the-same-time, method of teaching. And this can be much more than just "enrichment" by adding on projects, supplemental readings, "seminars", and field trips. We can individualize the instruction without confining the instruction to any one device which someone thinks is the universal panacea for all the ills of the educational scene at the time - even teaching machines and programmed learning!

Glaser's (10) discussion about effective individualized education listed a series of recommendations to use when individualizing instruction. They are: 1) redesign grade level boundaries and time limits for subject matter coverage, 2) well-defined sequences of behaviorally defined objectives as study guides for students, 3) adequate evaluation of a student's progress through a curriculum sequence, 4) instructional materials appropriate for self directed learning, 5) professional training of school personnel in student evaluation and guidance, and 6) use by teachers of student profiles, automation, and other special techniques to design the individualized program. Glaser's recommendations were recognized by the International Conference on Education in Chemistry in 1970 (11) that sent a directive to secondary schools to produce materials for the study of chemistry from a humanistic point of view.

The conference said that the best way to implement these recommendations and to humanize the curriculum is to individualize. The theory and philosophy of individualized instruction discussed by Glass (12), Rasmussen (13), McCarley (14) and Goodlad (15) agree with the outcome of the International Conference on Education in Chemistry. They further state that the teacher should become a partner, data source, observer and diagnostician.

A literature search of current research in individualized instruction in the sciences revealed few such programs in chemistry and none that seemed to fit the writer's description of an individualized program. Most programs were an elaborate self-pacing program usually designed around a text book. Tucker (16) supports the writer's conclusion that most individualized programs are self-pacing at different levels. He says that commercial "individualized" programs concentrate on only data input, primarily self-pacing with little effective evaluation to determine how the data are processed. He also stresses the need of teacher training and good teaching in order for individualizing to be effective in the classroom.

Tolpin (17) supports Glaser's and Tucker's observations with a survey study of high school chemistry students. From his studies, only about 10 percent of the students taking chemistry are science oriented; the other ninety percent of the students take the course for its educational value. A majority of the textbooks that discuss the procedures and techniques of high school chemistry provide a firm education for the college bound student. The average student that plunges enthusiastically into the subject quickly becomes perplexed and panics because too many of the signposts are unintelligible to him.

The literature search revealed only seven programs of individualized instruction in chemistry. Only one of the seven programs was studied statistically.

Perkins (18), Denton (19) and DeRose (20, 21) all develop individualized programs around the CHEM study (Chemical Education Material Study) curriculum. The programs were all self-paced laboratory oriented programs designed around a format of (1) work guides, (2) behavioral objectives, (3) evaluation on a point system, (4) task deadlines or time contracts, (5) small group interaction and (6) an effective teacher-pupil relationship. House (22) used a similar format except he made extensive use of multimedia and of experiment stations. The classroom was redesigned to meet the needs of the program. Unfortunately, none of the programs mentioned above went any further than the schools involved in the study.

Another type of program listed as individualized was developed by Powell (23). This was an individualized programmed instruction packet designed to provide a self-paced logical sequence of small steps and to allow for immediate confirmation or correction in order to help solve the problems created by the wide spread of abilities and interests among high school chemistry students.

Shavelson (24) did more than develop and report on a program. He carried out a study to compare the success of his individuzlized chemistry program with the traditional classroom lecture method of instruction. His study was not a statistical study but his findings stated that individualized instruction involving individual lectures and labs with small group discussions and self-pacing is superior to the traditional classroom lecture method.

The statistical study was done by Krockover (25). This study was similar to the ones done by Perkins (18), Denton (19), DeRose (20,21) and House (22) except that the CBA (Chemical Bond Approach) chemistry curriculum was used. His data indicated that the experimental (individualized) class did as well or significantly better (using analysis of covariance) at the 0.05 level than students enrolled in a group instruction CBA class as indicated on the ACS (American Chemical Society) Chemistry Test, TOUS (Test On Understanding Science) Test, the Watson Glaser Critical Thinking Test and CBA Standardized Achievement Test. He also found the students said that the greatest source of pressure to get work done in an individualized class was themselves. They worked harder in an individualized class but said that they liked the class. They also indicated that the class also gave them more responsibility for learning.

Even though none of these programs was a true individualized program, a real effort was made to meet the needs of the students through the different attempts to cope with individual differences. All of the programs indicated that the role of the teacher must change to that of a resource person from that of a lecturer or "spoon feeder".

Changes in length of class periods, scheduling on the basis of purpose and need, pupil programs based upon maturation, interest and achievement, varied instructional tools and new physical arrangements will not, themselves, bring about individualization of science instruction by teachers. However, they will provide teachers with the opportunity to better individualize and will facilitate its actual happening. Such changes are making it possible for teachers to have the freedom to organize their teaching for individuals and small groups. These innovations have and will continue to make it possible for teachers to utilize

a problem-solving approach to science teaching, and allow for greater involvement of students in the teaching-learning act. In so doing, teachers will be providing greater opportunities for students to experience success in school and to develop adequate concepts of themselves as individuals (26).

In summary, the literature shows much discussion about the merits of individualized instruction and how to individualize but has essentially no sound evidence to indicate the effectiveness of an individualized approach. In the field of chemistry, only one study was found that had a supportable evaluation. But using the writer's definition of individualizing, the study was done on a self-paced/independent study program. Most of the articles regarding curriculum studies are discussed from a subjective point of view. Also, after the study was completed, the curriculum or program was not followed through and no further study was done.

The lack of a thorough objective study of an individualized approach toward instruction in the literature indicates a need for such a study. Because of the current trend toward individualization of instruction, there is a need for studies of this type in many different subject fields. Therefore in view of the findings in the literature, the writer developed, pilot studied and field tested an individualized program in chemistry. The study is discussed in Chapters III through VI.

CHAPTER III

DESIGN OF THE RESEARCH

I. Hypotheses

Four hypotheses were designed to study the effects of the Individualized Chemistry Program on high school students. They are stated in the null form as follows:

1. There will be no significant difference between the experimental and control groups with respect to achievement in chemistry.

2. There will be no significant difference between experimental and control groups with respect to reported attitudes toward science.

3. There will be no significant difference between experimental and control groups with respect to reading ability.

4. There will be no significant difference between high and low achievers on the STEP Reading Test of either experimental or control groups with respect to achievement in chemistry.

II. Research Design

Each hypothesis was chosen to demonstrate the effectiveness or ineffectiveness of the Individualized Chemistry Program with respect to the three main objectives of the course: (1) achievement in chemistry, (2) attitude toward science courses, and (3) the slow student will achieve as much as the fast student if given enough time. From experience and observations, it appears that many slow students are slow because of their reading ability. If this is the case, a test of reading

ability using experimental and control groups would confirm this statement (27).

In the case of achievement, the literature provided no tests designed for individualized chemistry. The only criterion that could be used was the national ACS Chemistry Examination, which could be used to compare both groups, experimental and control, to a national norm. This test should indicate two things: (1) the comparison of achievement between groups (experimental and control) and (2) comparison to a national norm based on a traditional approach toward chemistry.

The traditional science courses cause many students to dislike science and to avoid science courses in college. This negative attitude toward science in students, which may have an effect on the feeling people have toward science, is used to indicate any effect the Individualized Chemistry course and the traditional course have on the attitude of the student toward science.

A student questionnaire is used as a formative evaluation of the program. It will be used to help improve the program for use in the future.

Because of the number of participating schools, randomization was possible, both in the selection of schools as experimental or control, and in the selection of classes within each school. Schools were grouped into matched pairs, then randomly designated as experimental or control.

This procedure approximates the Pre-test/Post-test Control Group Design No. 4 of the Campbell and Stanley series (28) shown below:

R	O	X	O
R	O		O

It is assumed that the control and experimental classes are very similar because all the students are high school students in Florida taking high school chemistry at the same time. If this assumption is correct, the threats to internal validity due to history, maturation, testing and instrumentation are controlled.

The effect of regression on internal validity is eliminated because the students were not chosen due to their scores on the pre-test.

Selection-maturation interaction is not controlled because the students were not randomly selected and may not be equivalent. An attempt to escape this problem was made by attempting to obtain experimental and control classes at the same school or in the same area as an attempt to obtain students from the same type of population. Also because the classes were randomly selected to be experimental or control --these included small rural schools to large city schools---the effect of this source of internal invalidity can be decreased significantly.

Testing and X interaction as a threat to external validity does not seem to be a threat since the amount of time testing, compared to the amount of time X is in effect, is small so the student should remember little of the tests.

The threat of selection and X interaction is controlled since the generalizations will be limited to the areas from which the schools are located and by random selection of schools.

The effect of reactive arrangements on external validity should be limited because most of the schools participating in the program only

have one class of chemistry and the students should not be sensitive toward the experimentation (29-31).

A statistical analysis, described in the data analysis section, will be used to test the hypothesis and to check the content validity of the study.

CHAPTER IV

DATA ACQUISITION

I. Instrumentation

Three test instruments and one questionnaire are used for the evaluation of the study. They are as follows:

1. ACS Cooperative Chemistry Examination.

   This test is used to test the hypothesis regarding achievement. No test had been found to evaluate the achievement of a student's progress in an individualized chemistry course. Since the course is designed for a student who is college bound, a final evaluation with that in mind was needed. The ACS Examination was designed to evaluate a student on what he should know in chemistry to enter college. This test will compare the experimental and control students with the national average of all high school students taking chemistry in America. The Kuder-Richardson Formula 21 reliabilities for the norms groups are in the 0.90's for this test (32).

2. Sequential Test of Educational Progress Reading Test.

   This test is used to test the reading level of the student in order to determine if he has a high or low reading ability. This information will be used to correlate with achievement. The STEP Reading Test was chosen because of its long-term use and accessibility. Using the Spearmen-Brown formula, the reliability of the Form 3A Reading Test ranges from 0.72 to 0.86 (33).

3. Any-School-Subject Attitude Test (Figure 12).

   This test is used to determine the attitude of students toward chemistry. Silance and Remmers (34) report equivalent-forms reliabilities ranging from 0.81 to 0.90 using both high school and college students and using different school subjects as attitudinal referents. This scale has been validated using criterion groups measured for interest and values.

ATTITUDE TEST PRE

There are no right or wrong answers to these questions. People differ in their opinions on them. Indicate your opinion by blacking in with #2 pencil the number on the answer sheet which corresponds most closely with your feelings.

1 = Agree
2 = Disagree

1. No matter what happens, chemistry always comes first.
2. I hate chemistry.
3. I would rather study chemistry than eat.
4. Chemistry is the most undesirable subject taught.
5. I love to study chemistry.
6. I detest chemistry.
7. Chemistry is of great value.
8. I look forward to chemistry with horror.
9. Chemistry has an irresistible attraction for me.
10. Chemistry is disliked by all students.
11. I really enjoy chemistry.
12. It is a punishment for anybody to take chemistry.
13. Chemistry is profitable to everybody who takes it.
14. Chemistry is a waste of time.
15. Chemistry develops good reasoning ability.
16. Chemistry is based on "foggy" ideas.
17. Chemistry is very practical.
18. I would not advise anyone to take chemistry.
19. Any student who takes chemistry is bound to be benefited.
20. I have seen no value in chemistry.
21. Chemistry teaches me to be accurate.
22. I have no desire for chemistry.
23. Chemistry is a universal subject.
24. Chemistry reminds me of Shakespeare's play--"Much Ado About Nothing".
25. Chemistry is a good subject.
26. Chemistry is very dry.
27. All of our great men studied chemistry.
28. Chemistry does not teach you to think.
29. Chemistry is a cultural subject.
30. I am not interested in chemistry.
31. All lessons and all methods used in chemistry are clear and definite.
32. The minds of students are not kept active in chemistry.
33. Chemistry is O.K.
34. Mediocre students never take chemistry; so it should be eliminated from schools.
35. I am willing to spend my time studying chemistry.
36. I could do very well without chemistry.
37. Chemistry is not receiving its due in public high schools.
38. My parents never had chemistry; so I see no merit in it.
39. Chemistry saves time.
40. Chemistry will benefit only the brighter student.
41. Chemistry is not a bore.
42. I haven't any definite like or dislike for chemistry.
43. Chemistry is a good pastime.
44. I am careless in my attitude toward chemistry, but I would not like to see this attitude become general.
45. I don't believe chemistry will do anybody any harm.

Figure 12: Any-School-Subject Attitude Test

ATTITUDE TEST POST

There are no right or wrong answers to these questions. People differ in their opinions on them. Indicate your opinion by blacking in with #2 pencil the number on the answer sheet which corresponds most closely with your feelings.

1 = Agree
2 = Disagree

1. I am "crazy" about chemistry.
2. Chemistry is the worst subject taught in school.
3. The very existence of humanity depends upon chemistry.
4. Words can't express my antagonism toward chemistry.
5. If I had my way, I would compel everybody to study chemistry.
6. No sane person would take chemistry.
7. Chemistry is one of the most useful subjects I know.
8. Chemistry is all bunk.
9. I believe chemistry is the basic subject for all high school courses.
10. Chemistry is more like a plague than a study.
11. Chemistry is one subject that all young Americans should know.
12. Nobody likes chemistry.
13. Chemistry fascinates me.
14. Chemistry has no place in the modern world.
15. The merits of chemistry far outweigh the defects.
16. Chemistry can't benefit me.
17. Chemistry gives pupils the ability to interpret situations they will meet in life.
18. All of the material in chemistry is very uninteresting.
19. Chemistry will help pupils socially as well as intellectually.
20. The average student gets nothing worth having out of chemistry.
21. Chemistry makes me efficient in school work.
22. Chemistry does not hold my interest at all.
23. There are more chances for development of high ideals in chemistry.
24. Chemistry seems to be a necessary evil.
25. Chemistry is interesting.
26. Chemistry is dull.
27. Chemistry teaches methodical reasoning.
28. Chemistry interferes with developing.
29. Chemistry serves the needs of a large number of boys and girls.
30. Chemistry has numerous limitations and defects.
31. All methods used in chemistry have been thoroughly tested in the classroom by experienced teachers.
32. Chemistry does not motivate the pupil to do better work.
33. Chemistry has its merits and fills its purpose quite well.
34. No definite results are evident in chemistry.
35. Every year more students are taking chemistry.
36. To me chemistry is more or less boring.
37. Chemistry aims mainly at power of execution or application.
38. No student should be concerned with the way chemistry is taught.
39. Chemistry is not based on untried theories.
40. Chemistry is all right, but I would not take any more of it.
41. I think chemistry is amusing.
42. My likes and dislikes for chemistry balance one another.
43. Chemistry has its drawbacks, but I like it.
44. Chemistry doesn't worry me in the least.
45. Chemistry might be worthwhile if it were taught right.

Figure 12 (Cont'd.)

4. Student Questionnaire (Figure 11).

The questionnaire was designed by M. Betkouski, a graduate student in Education participating in the evaluation of the pilot study of the program (35). The reliability of the questionnaire appears to be sufficient because the pre- and post-test results during the pilot program and first year of field testing were consistent. The questionnaire is valid because the results were relevant to the design of the questionnaire. This questionnaire will be used only for formative evaluation.

II. Sampling

The sample for this study consists of 18 schools in the experimental program consisting of 849 students and 11 control schools consisting of 703 students for a total student population of 1552. The control and experimental classes were randomly selected from the pool of schools in the State of Florida that indicated a willingness to participate as an experimental or control school in the Individualized Chemistry Program. The pool of schools were selected from schools in 44 Florida counties subscribing to the Florida Educational Research and Development Council (FERDC). These counties range from the Panhandle to the Southern tip of Florida and are representative of the State's population. With respect to the threat of selection and X interaction to external validity, all schools who were contacted volunteered to participate in the program. This threat will be minimal because the universe of schools from which generalizations will be made will only be the schools involved in the study.

The threat of reactive arrangements to external validity may have some effect on the study because most of the teachers participating wanted to teach an experimental class. Not all teachers were able to teach an experimental class or both experimental and control classes due

to random selection of classes. The experimental teachers may be more enthusiastic than teachers teaching the traditional course.

The Pre-test/Post-test Control Group Design was chosen because of its ability to eliminate most restricting variables with respect to internal validity. Since two equivalent and valid forms of each test were available, pre- and post-testing was desirable because it would not only give mean gains but also give information on achievement gains that had been requested by many of the participating teachers. It also presented less confusion for the teacher, hopefully eliminating data mix-ups.

III. Data Collection

Data from each group are obtained during a pre- and post-testing period. The teachers administer the tests to their classes following a set of testing instructions. All testing was done within a week of the testing date.

All data were returned to the research team and underwent evaluation. The results of the evaluation are discussed in Chapters V and VI.

IV. Method Of Data Analysis

A statistical analysis of the data, using the IBM-370 computer, will be done in the following manner:

1. Population Control:

    I. T - Test on pre-test ACS
    II. T - Test on pre-test Attitude
    III. T - Test on pre-test STEP Reading

2. Correlation matrix based on Pearson's Coefficient of Correlation (r) to study the relationships between achievement and the variables, attitude and reading ability, on both experimental and control groups.

3. Analysis of covariance test for significant difference between the control and experimental groups in terms of the dependent variables, achievement in Chemistry, attitude toward science and reading ability.

CHAPTER V

DATA ANALYSIS AND RESULTS

I. Population

The population at the beginning of the study consisted of 29 schools: 18 experimental schools containing 849 students and 11 control schools containing 703 students. Pre-tests in all the evaluations were given to the total population of 1552 students. At the end of the study when the post-tests were returned, it was found that only 587 students had matched test scores: 305 experimental students and 282 control students. When this population was examined, it was found that the 305 experimental students came from 13 different classrooms and the 282 control students came from 8 different classrooms providing a total classroom population of 21 for the analysis of this study.

The basic population used in this study is the classroom unit. This unit was chosen because of the desirability of retaining the normal classroom selection of students found in each of the study schools. This requires discussion of results to be in terms of only the population schools and classrooms and not in terms of the students. Students were not randomly selected for the experimental and control classrooms; but rather the classrooms were randomly selected to be either experimental or control.

The experimental and control student population is used in part of the analysis described later in this chapter. It is recognized that

these data were not randomly selected and are therefore to be interpreted with caution. These data are used only as a means to better describe the interactions that were found to be significant.

Test for homogeneity of population was done using the "T" test as discussed in Kirk (36). The "T" test was done on comparing the experimental classes with the control classes. The "T" value was found to be negative for all three tests; therefore, $H_0 : \mu_1 = \mu_2$ for the study population is accepted.

II. Analysis Of Covariance

Hypothesis one was examined using the ACS Chemistry Test comparing the post-test results of the experimental and control classes using analysis of covariance. The level of significance chosen was the 10 percent level of confidence.

Analysis of covariance was done using the ACS post-test as the fixed variable and the STEP pre-test and the ACS pre-test as covariates. The "F" value for 1 and 17 degrees of freedom was found to be significant beyond the 0.1 level (Table 1).

A plot of the ACS pre- and post-test class means was done to indicate the direction of the significance (Figure 13). This plot shows a net gain by both experimental and control groups but a significantly greater net gain by the control group. Hypothesis one is not accepted.

Hypothesis two was examined using the All-School-Subject Attitude test in the same manner as with the ACS test. The test consists of 45 agree-disagree type statements, half of which are positive and the other

Table 1

Analysis Of Covariance Using The ACS Pre-Test And The
STEP Pre-Test As Covariates
With The ACS Post-Test As The Fixed Variable

Source	dF	YY	Sum Of Squares (Due)	Sum Of Squares (About)	dF	Mean Square
Treatment (between)	1	2.9966				
Error (within)	19	35.7029	12.9375	22.7653	17	1.3391
Treatment + Error (total)	20	38.6995	11.3717	27.3278	18	
Difference For Testing Adjusted Treatment Means				4.5625	1	4.5625

$F_{1,17} = 3.407$ * n = 21

* Significant At The 0.1 Level

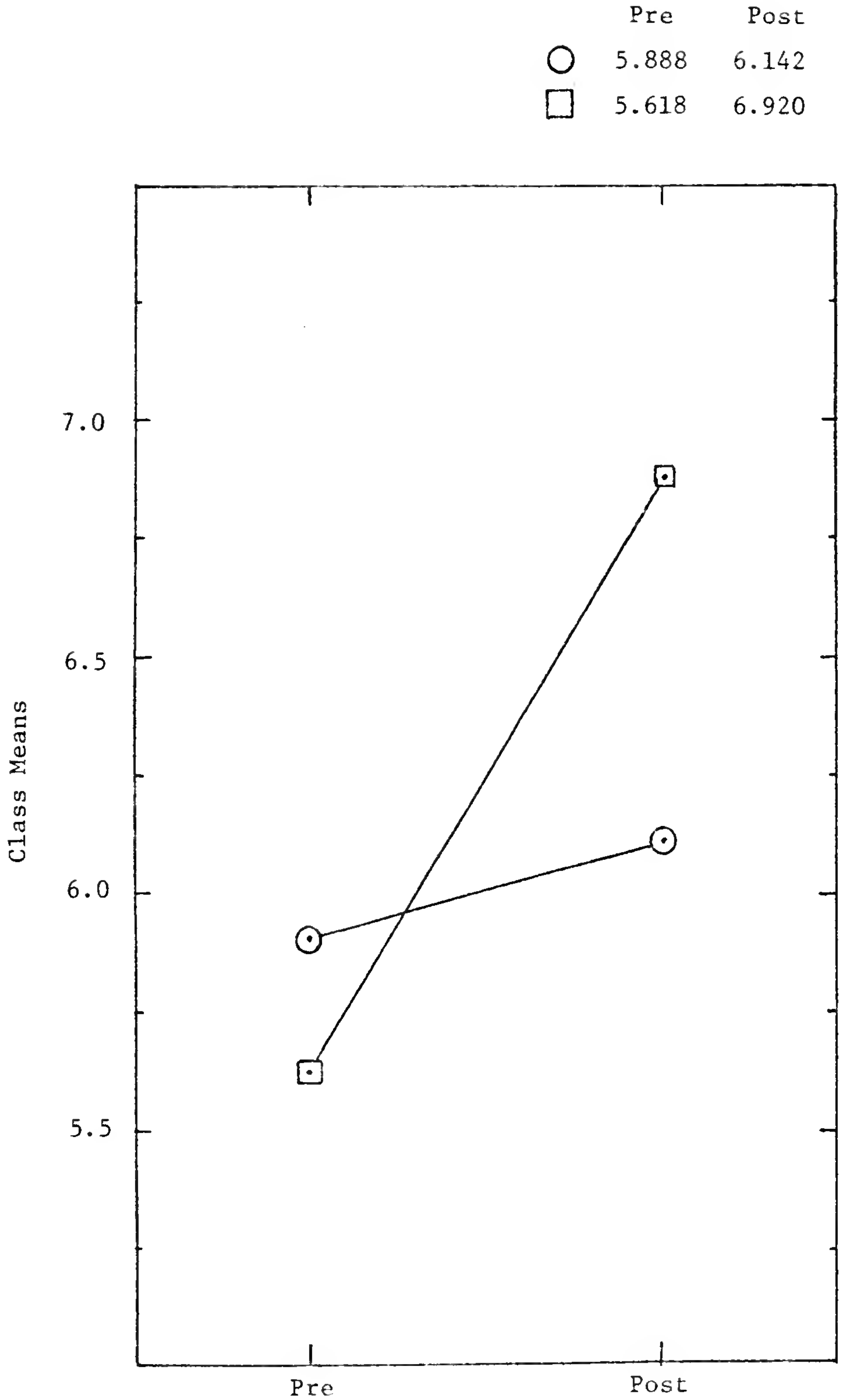

Figure 13: ACS Pre-, Post-test Class Means
O - Experimental Group
□ - Control Group

half negative attitude statements. An agree score on a positive statement received a plus one score, while an agree response for a negative statement received a negative one score. A positive attitude was determined as any positive score while a negative attitude was determined by any negative score. Analysis of covariance was done using the Attitude post-test as the fixed variable and the ACS pre-test as the covariate. The "F" value for 1 and 18 degrees of freedom was found to be significant beyond the 0.1 level (Table 2).

A plot of the Attitude test pre- and post-test means (Figure 14) was then done to determine the direction of significance. The plot showed an overall regression in both the experimental and control groups with the greatest regression in the control group. Hypothesis two is not accepted.

Analysis of covariance was also done to test hypothesis three using the STEP post-test as the fixed variable and the ACS pre-test and the Attitude pre-test as the covariates. The "F" test was found to be not significant at the 0.1 level. A plot of the STEP test pre- and post-test means (Figure 15) shows little difference in the gain of the experimental and control groups. Therefore hypothesis number three is accepted.

III. Correlation

A correlation matrix was done comparing the pre-test, post-test and difference in the ACS, STEP and Attitude tests for both the experimental and control (Tables 3 and 4). With a population of 305 students in the experimental program and 282 in the control program, correlations

Table 2

Analysis Of Covariance Using The ACS Pre-Test As The Covariate
With The Attitude Post-Test As The Fixed Variable

Source	dF	YY	Sum Of Squares (Due)	Sum Of Squares (About)	dF	Mean Square
Treatment (between)	1	1.0105				
Error (within)	19	6.5201	0.3217	6.1984	18	0.3444
Treatment + Error (total)	20	7.5306	0.0703	7.4603	19	
Difference For Testing Adjusted Treatment Means				1.2619	1	1.2619

$F_{1,18} = 3.665$ *

n = 21

* Significant At The 0.1 Level

	Pre	Post
○	5.736	5.592
□	6.029	5.430

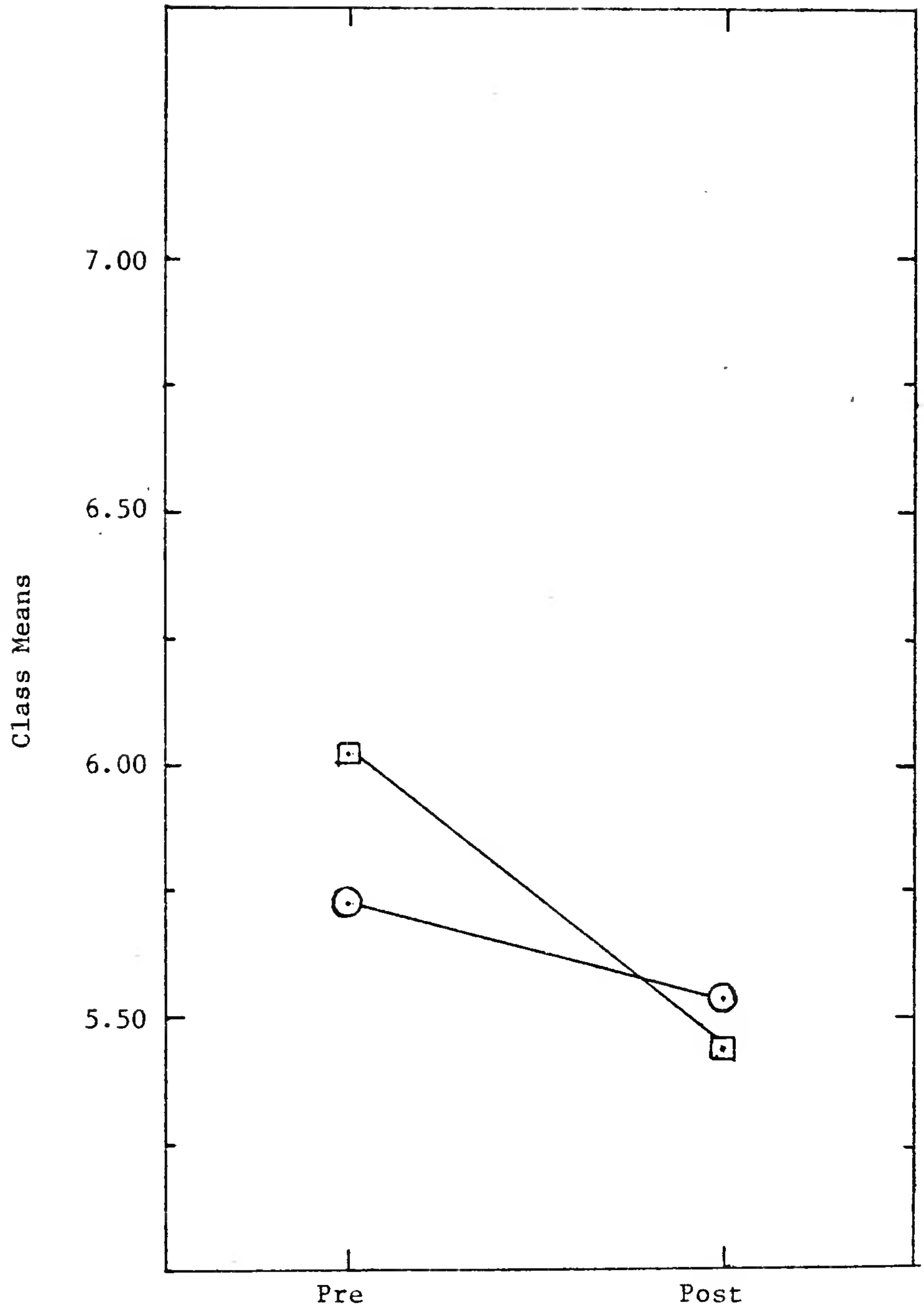

Figure 14: Attitude Pre-, Post-test Class Means
○ - Experimental Group
□ - Control Group

	Pre	Post
○	24.916	28.393
□	25.166	29.311

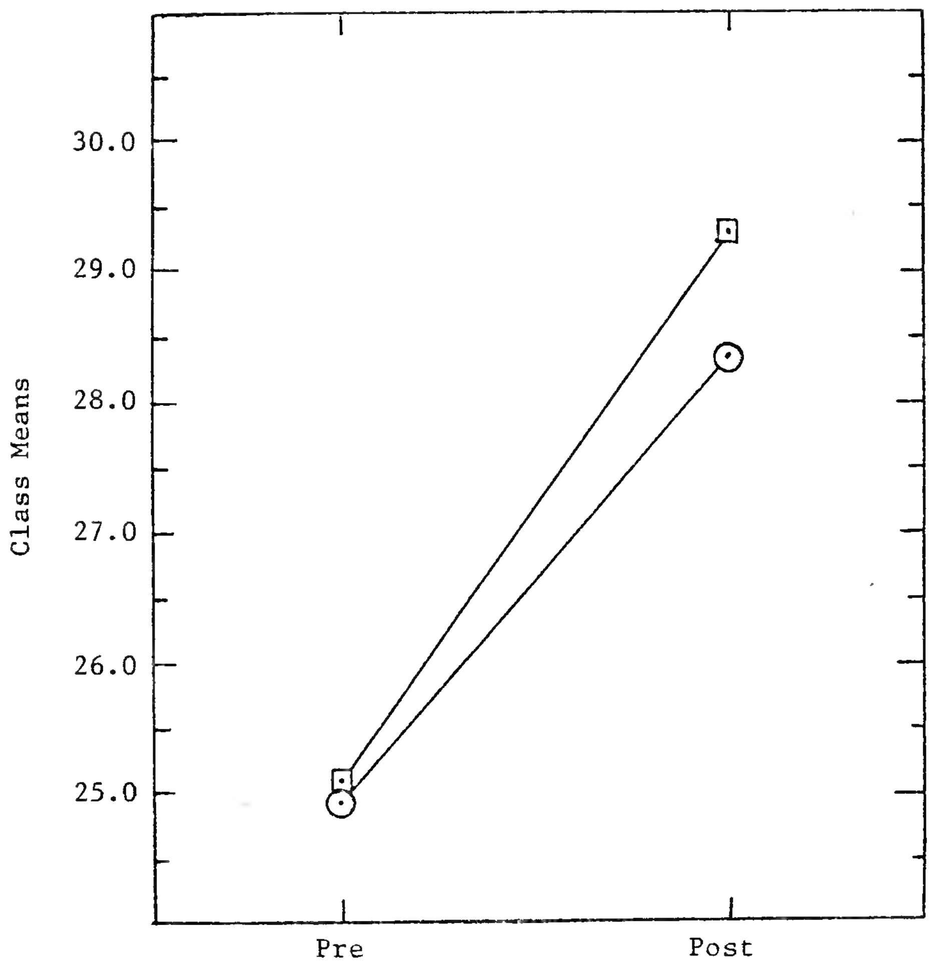

Figure 15: STEP Pre-, Post-test Class Means
○ - Experimental Group
□ - Control Group

Table 3

Correlation Matrix For The Experimental Schools

	ACS Pre-Test	ACS Post-Test	STEP Pre-Test	STEP Post-Test	Attitude Pre-Test	Attitude Post-Test	ACS Difference	STEP Difference	Attitude Difference
ACS Pre-Test	1.0000	-	-	-	-	-	-	-	-
ACS Post-Test	0.3386 *	1.0000	-	-	-	-	-	-	-
STEP Pre-Test	-0.1049	-0.0639	1.0000	-	-	-	-	-	-
STEP Post-Test	-0.1005	0.0099	0.4709 *	1.0000	-	-	-	-	-
Attitude Pre-Test	0.0378	-0.0859	-0.0369	-0.0302	1.0000	-	-	-	-
Attitude Post-Test	0.1373	0.0442	0.0013	-0.0333	0.1421	1.0000	-	-	-
ACS Difference	-0.6455 *	0.4899 *	0.0459	0.1010	-0.1041	-0.0917	1.0000	-	-
STEP Difference	-0.0015	0.0701	-0.4723 *	0.5552 *	0.0046	-0.0345	0.0577	1.0000	-
Attitude Difference	0.0703	0.1005	0.0302	-0.0004	-0.6904 *	0.6180 *	0.0156	-0.0289	1.0000

* Significant

Table 4

Correlation Matrix For The Control Schools

	ACS Pre-Test	ACS Post-Test	STEP Pre-Test	STEP Post-Test	Attitude Pre-Test	Attitude Post-Test	ACS Difference	STEP Difference	Attitude Difference
ACS Pre-Test	1.0000	-	-	-	-	-	-	-	-
ACS Post-Test	0.2851 *	1.0000	-	-	-	-	-	-	-
STEP Pre-Test	-0.0846	0.0562	1.0000	-	-	-	-	-	-
STEP Post-Test	-0.1079	0.0714	0.5007 *	1.0000	-	-	-	-	-
Attitude Pre-Test	-0.1511	0.0336	0.1222	0.0857	1.0000	-	-	-	-
Attitude Post-Test	-0.0161	-0.0556	0.0725	0.0113	0.1651	1.0000	-	-	-
ACS Difference	-0.6901 *	0.4969 *	0.1190	0.1515	0.1622	-0.0274	1.0000	-	-
STEP Difference	-0.0078	0.0049	-0.6143 *	0.3755 *	-0.0527	-0.0673	0.0107	1.0000	-
Attitude Difference	0.1085	-0.0668	-0.0430	-0.0582	-0.6831 *	0.6066 *	-0.1486	-0.0070	1.0000

* Significant

above 0.15 are significant. The correlation matrix was done in order to better understand the interactions that caused the significance in the previous analysis. Both correlation matrices show many correlations between the pre- and post-test evaluations of all the tests and the differences in all the tests (see the asterisk correlations). Because of the difficulty in the interpretation of these correlations, an analysis of variance using a factorial design was used to help determine the interaction effects in this study.

IV. Trend Analysis

A three way factorial design was set-up as shown in Figure 16. This design was chosen because it is sensitive to interactions and could easily be used to compare the students in the high, medium and low groups. As mentioned before the results of this analysis must be treated with caution because the student population was not chosen randomly. The main purpose of this evaluation is to generate information that is helpful in analyzing interactions that could cause the significant results reported earlier.

The analysis of variance by factorial design was done three times, one each for the ACS pre- and post-tests, the STEP pre- and post-tests and the Attitude pre- and post-tests. For each analysis, the data were grouped into three equal groups, high, medium and low, based on the pre-test scores. Since the program used could only handle equal "n's", twenty-three students were randomly selected out of the experimental and control groups to give each cell a population of twelve students, six experimental and six control. Each cell block was cycled forty-seven

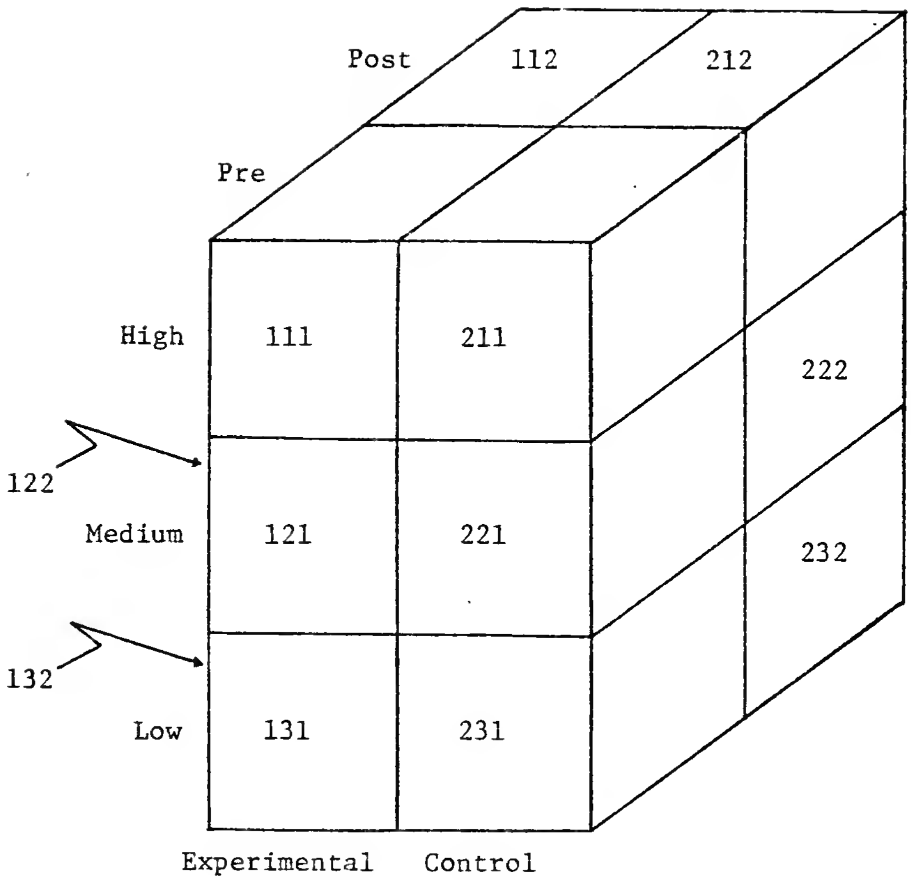

Figure 16: 2 X 3 X 2 Model For The Factorial Design

times making the total population for the analysis five hundred and sixty-four.

Interactions that received meaningful "F" values were checked, using the Scheffé procedure, with confidence intervals. Then plots of the cell means of the interactions were done to illustrate the behavior of the three groupings of students.

The first factorial design used the STEP test (Table 5). Using the Scheffé method for determining confidence limits, the high and medium groups for the significant (2,3) interaction fell within the confidence limit set at 99 percent. The low group fell outside of the limit.

The pre- and post-test means were then plotted for the (2,3) interaction (Figure 17). As observed from the plot, the high and medium group changed little with respect to the net difference between the pre- and post-tests. The low group shows a disordinal interaction with the medium group and indicates a large net gain over the medium group.

Pre- and post-test means for the experimental and control were plotted for the (1,3) interaction in Figure 18. A slight disordinal interaction is evident but both experimental and control show a net gain from pre- to post-test. A plot of the (1,2,3) interaction between experimental and control; high, medium and low; and pre- and post-test means was done (Figure 19). This plot reflects the interactions shown on Figures 17 and 18. It also shows a disordinal interaction between the medium experimental and the medium control.

The second factorial design used the ACS test (Table 6). Using the Scheffé method for all the significant interactions, the high group in the (2,3) interaction and the (1,2,3) interaction fell outside

Table 5

First Factorial Design Using The STEP Test

Source Of Variation		dF	Sum Of Squares	Mean Squares	F
Experimental, Control	(1)	1	0.08690	0.08690	0.011
High, Medium, Low	(2)	2	1028.79175	514.39575	52.198 *
Pre, Post	(3)	1	1420.25974	1420.25952	171.725 *
Interaction Between	(1,2)	2	22.76985	11.38492	1.377
Interaction Between	(1,3)	1	27.70433	27.70432	3.350
Interaction Between	(2,3)	2	371.32214	185.66106	22.449 *
Interaction Between	(1,2,3)	2	5.26147	2.63074	0.3181
Within Replicates		552	4565.25781	8.27039	
TOTAL		563	7441.45312		

* Significant At The 0.01 Level

Pre	27.777	25.043	23.138
Post	29.851	27.021	28.606

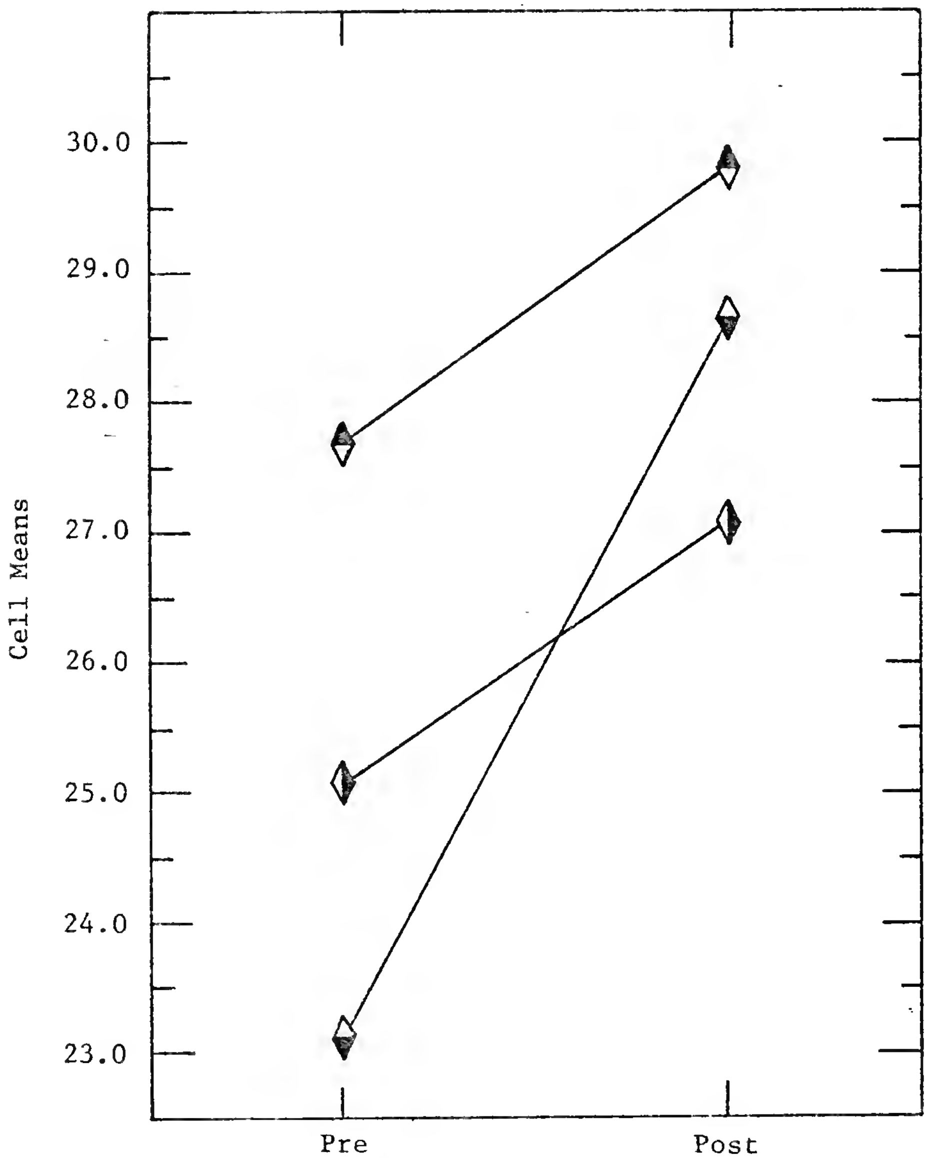

Figure 17: STEP Test:
Interaction Between Variable 2 (High, Medium and Low) and Variable 3 (Pre-, Post-test)
- High, - Medium, - Low

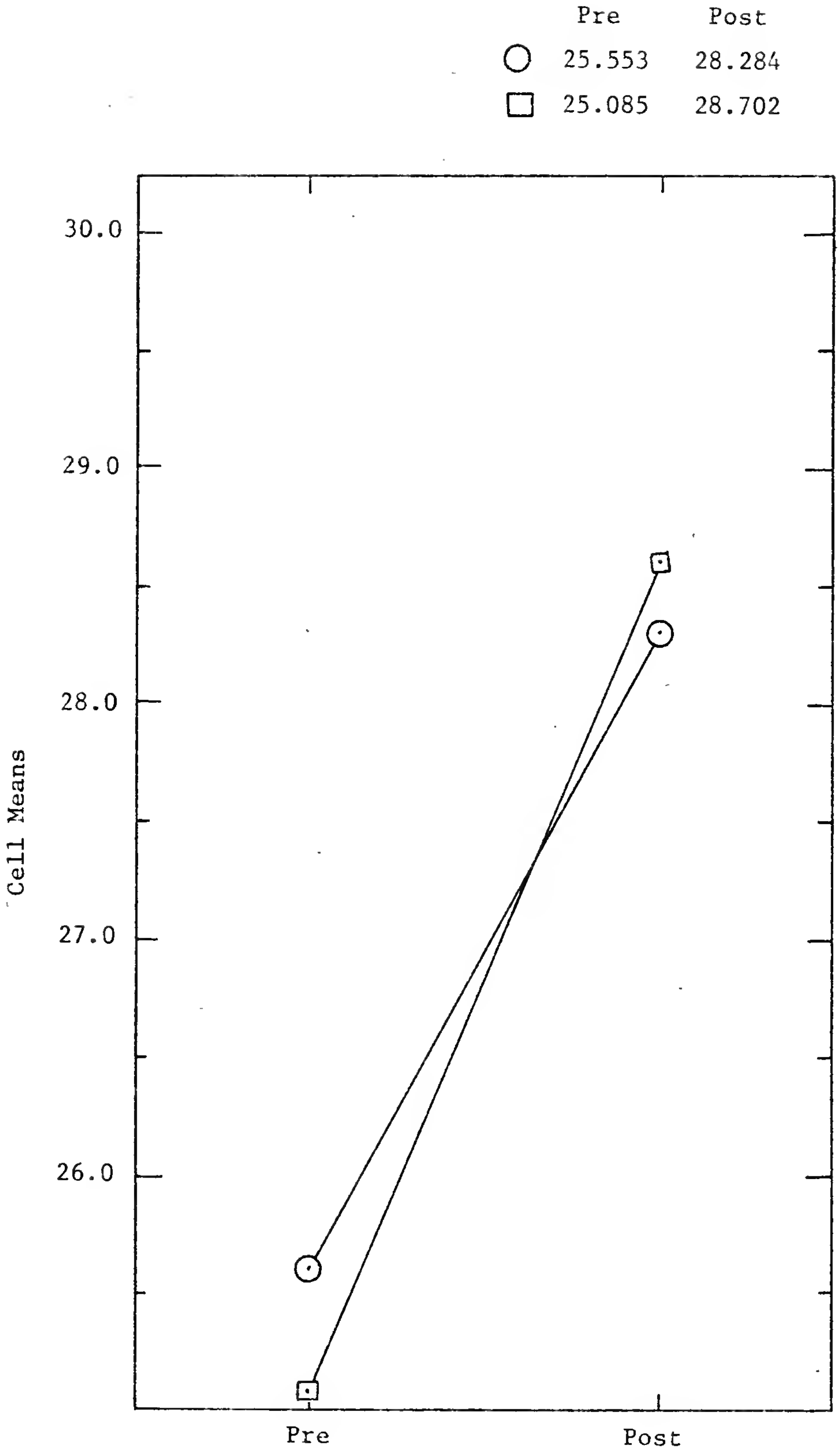

Figure 18: STEP Test:
Interaction Between Variable 1 (Experimental and Control) and Variable 3 (Pre-, Post-test)
O - Experimental Group, □ - Control Group

Pre	28.170	27.383	25.149	24.936	23.340	22.936
Post	29.915	29.787	26.404	27.638	28.532	28.681

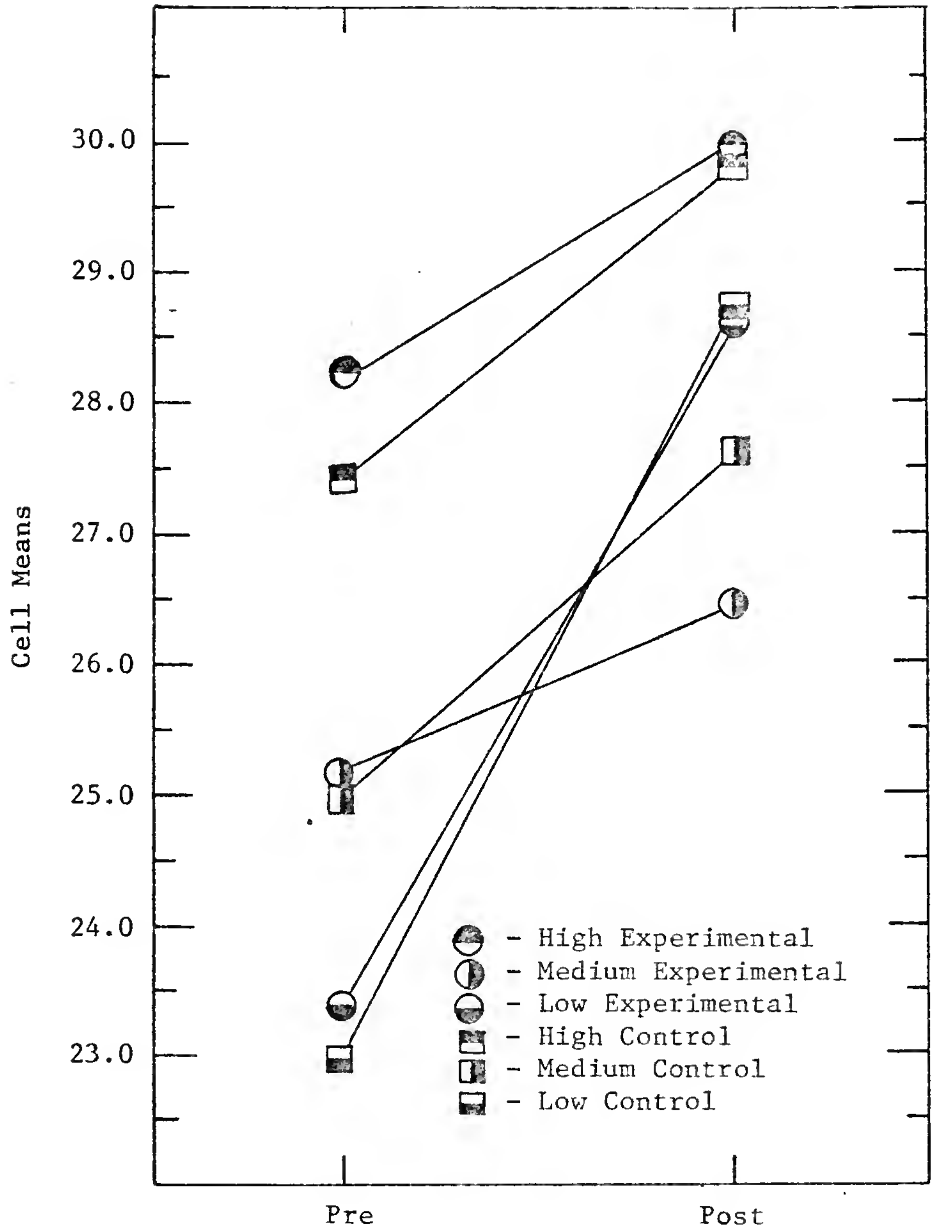

Figure 19: STEP Test: Interaction Between Variable 1 (Experimental and Control), Variable 2 (High, Medium and Low) and Variable 3 (Pre-,Post-test)

Table 6

Second Factorial Design Using The ACS Test

Source Of Variation		dF	Sum Of Squares	Mean Squares	F
Experimental, Control	(1)	1	90.56028	90.56027	21.204 *
High, Medium, Low	(2)	2	1675.29068	837.64526	196.130 *
Pre, Post	(3)	1	217.19859	217.19858	50.856 *
Interaction Between	(1,2)	2	145.54602	72.77301	17.039 *
Interaction Between	(1,3)	1	81.19864	81.19864	19.012 *
Interaction Between	(2,3)	2	588.78012	294.38989	68.930 *
Interaction Between	(1,2,3)	2	44.38379	22.19189	5.196 *
Within Replicates		552	2357.51904	4.27087	
TOTAL		563	5200.47656		

* Significant At The 0.01 Level

the confidence limits. Plots were done for interaction (2,3), interaction (1,3) and interaction (1,2,3) (Figures 20, 21 and 22). These plots show two points clearly:

1. The high group in the experimental program had a net loss between the pre- and post-tests.

2. The control group had a greater net gain between the pre- and post-tests.

The third factorial design used the Attitude test (Table 7). The Scheffé method for confidence levels showed no significance for interaction (2,3). A study of the plots in Figures 23, 24 and 25 shows:

1. A disordinal interaction between the high and medium group.

2. The experimental and control within the high, medium and low groups show little net gain.

3. The experimental group shows a net gain over the control group.

The fourth factorial design (Figure 26) compared the high and low reading achievers, as measured by the STEP pre-test, with their achievement in chemistry as measured by the ACS pre- and post-tests (Table 8). Population for this design was 376 students: 138 experimental and 138 control. The Scheffé method for confidence levels showed no significance for interaction between experimental and control, and for interaction between the pre and post results. A study of Figures 27, 28 and 29 shows:

1. The high and low readers in the experimental and control groups show nearly equal net gain in chemistry achievement.

2. There is little difference between the high and low reading achievers on the ACS pre- and post-tests.

3. There is a slight disordinal interaction between the high control group and the low control group.

Therefore, from these observations, hypothesis four is accepted.

	High	Medium	Low
Pre	9.074	4.713	2.489
Post	7.500	6.798	5.702

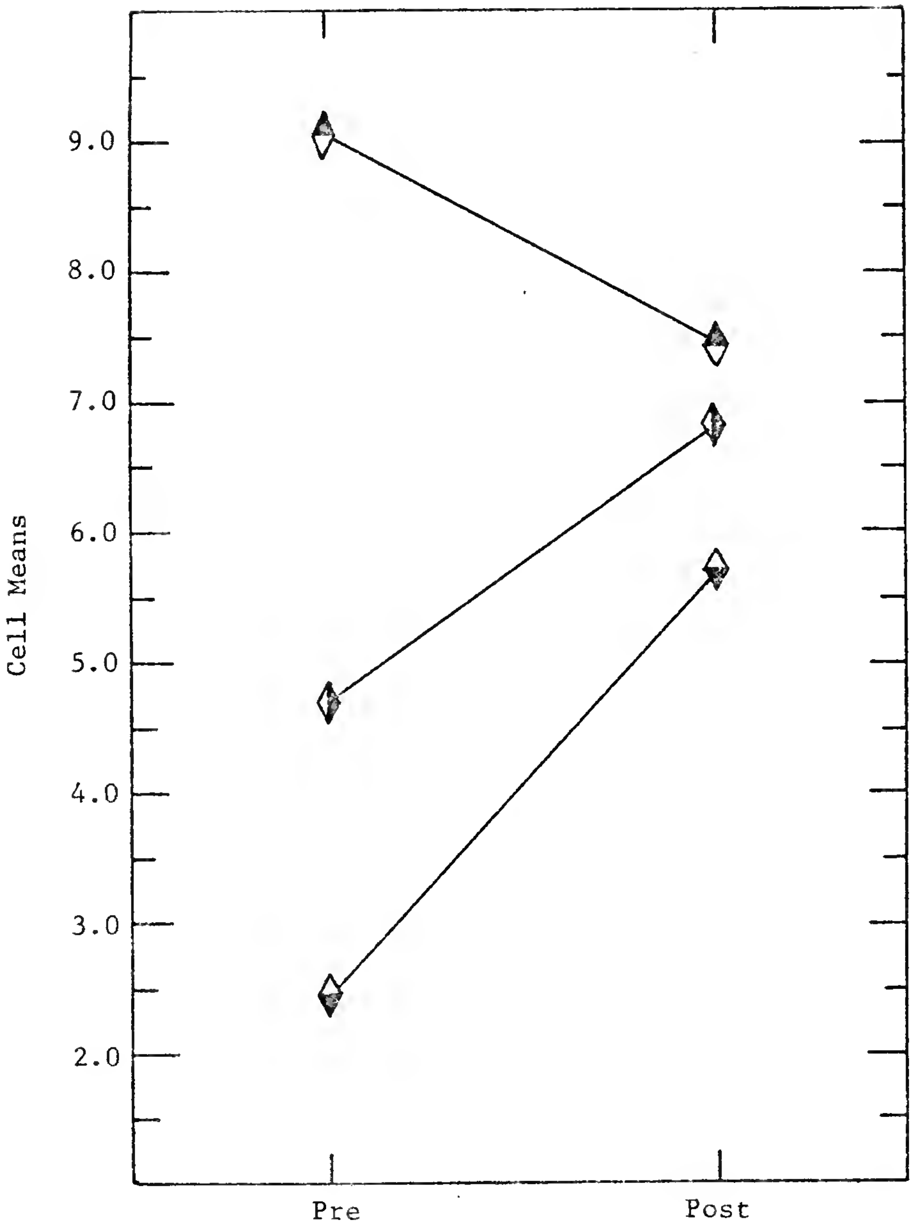

Figure 20: ACS Test:
Interaction Between Variable 2 (High, Medium and Low) and Variable 3 (Pre-, Post-test)
- High, - Medium, - Low

	Pre	Post
○	5.404	5.887
□	5.447	7.447

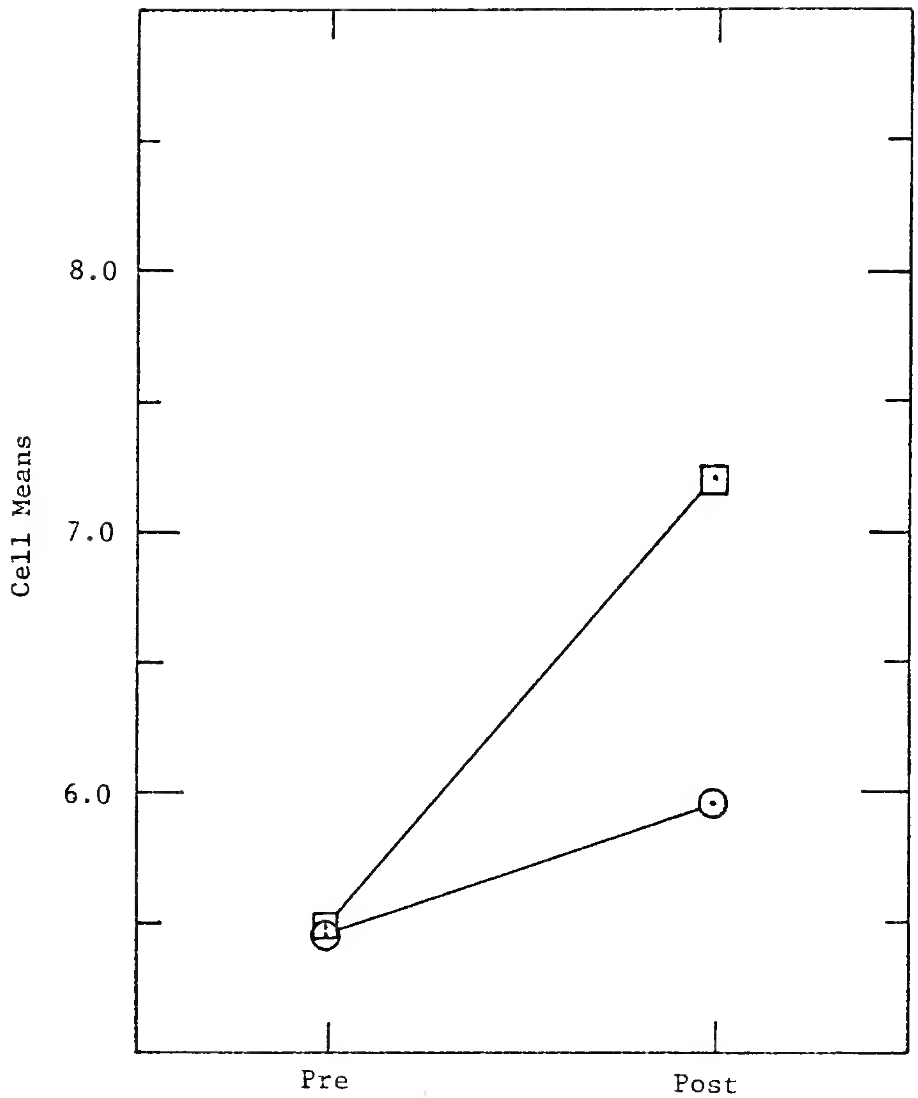

Figure 21: ACS Test:
Interaction Between Variable 1 (Experimental and Control) and Variable 3 (Pre-, Post-test)
○ - Experimental Group, □ - Control Group

	High Experimental	High Control	Medium Experimental	Medium Control	Low Experimental	Low Control
Pre	10.128	8.021	4.340	5.085	1.745	3.234
Post	7.000	8.000	6.106	7.489	4.553	6.851

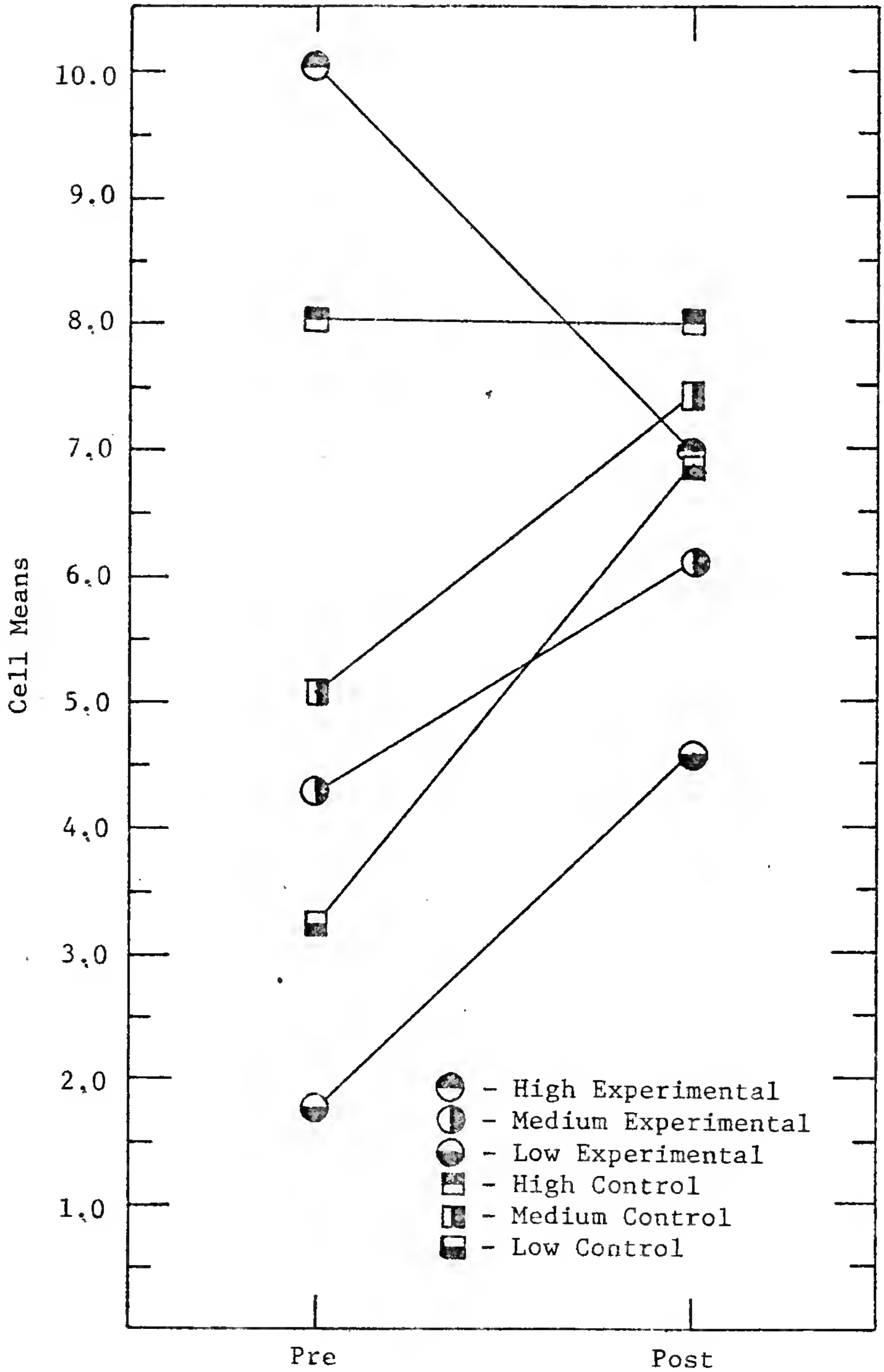

Figure 22: ACS Test: Interaction Between Variable 1 (Experimental and Control), Variable 2 (High, Medium and Low) and Variable 3 (Pre-, Post-test)

Table 7

Third Factorial Design Using The Attitude Test

Source Of Variation		dF	Sum Of Squares	Mean Squares	F
Experimental, Control	(1)	1	0.00177	0.00177	0.246
High, Medium, Low .	(2)	2	1.43070	0.71535	9.952 *
Pre, Post	(3)	1	0.04794	0.04794	0.667
Interaction Between	(1,2)	2	0.00557	0.00278	0.387
Interaction Between	(1,3)	1	0.00113	0.00113	0.016
Interaction Between	(2,3)	2	0.87175	0.43587	6.064 *
Interaction Between	(1,2,3)	2	0.00684	0.00342	0.048
Within Replicates		552	39.68007	0.07188	
TOTAL		563	42.04578		

* Significant At The 0.01 Level

Pre	0.565	0.460	0.379
Post	0.437	0.514	0.397

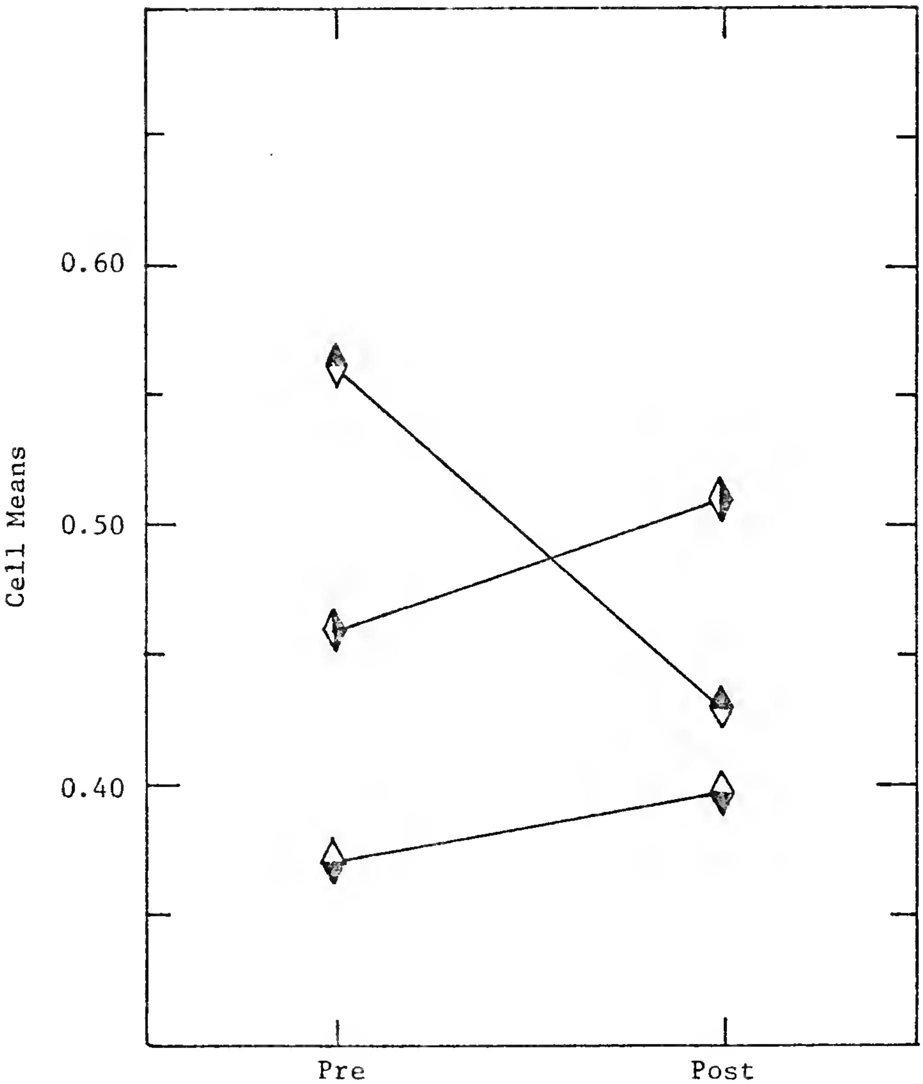

Figure 23: Attitude Test:
Interaction Between Variable 2 (High, Medium and Low) and Variable 3 (Pre-, Post-test)
- High, - Medium, - Low

	Pre	Post
O	0.468	0.452
□	0.467	0.446

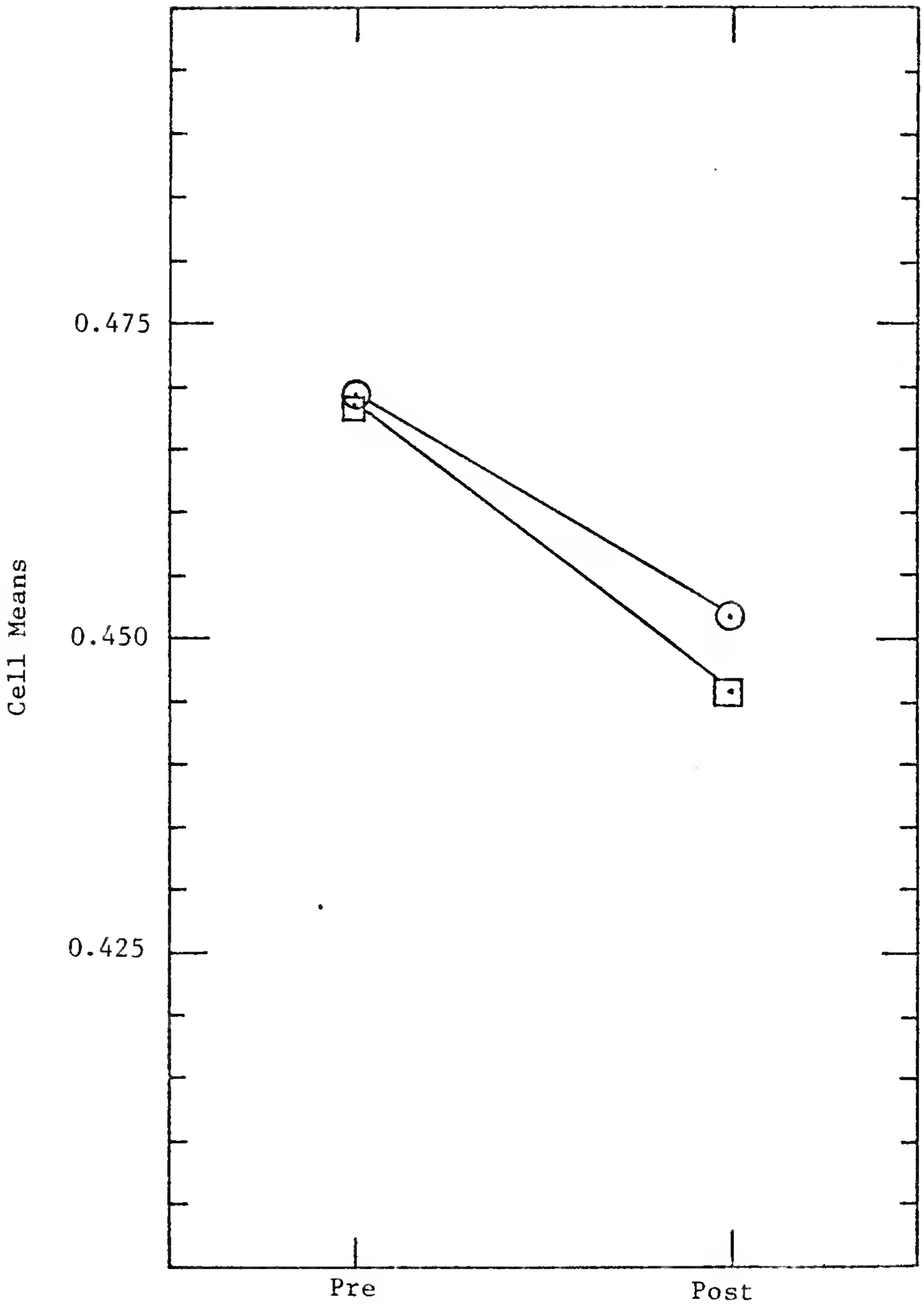

Figure 24: Attitude Test:
Interaction Between Variable 1 (Experimental and Control) and Variable 3 (Pre-, Post-test)
O - Experimental Group, □ - Control Group

Pre	0.568	0.562	0.466	0.453	0.370	0.387
Post	0.443	0.432	0.515	0.513	0.400	0.394

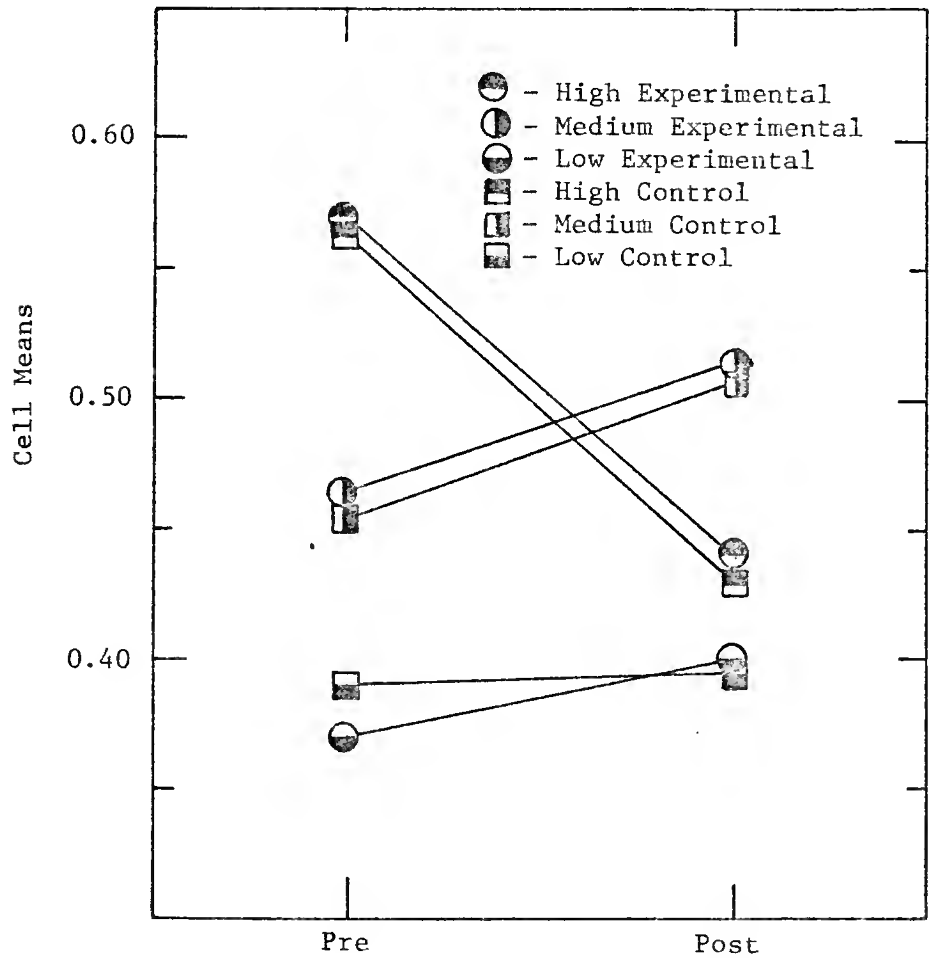

Figure 25: Attitude Test: Interaction Between Variable 1 (Experimental and Control), Variable 2 (High, Medium and Low) and Variable 3 (Pre-, Post-test)

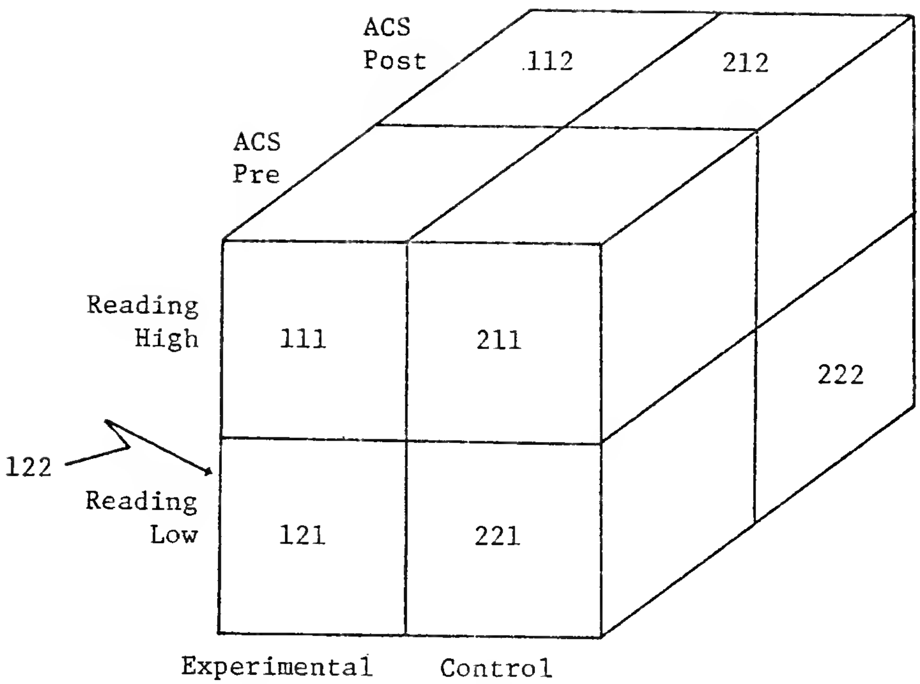

Figure 26: 2 X 2 X 2 Model For The Factorial Design

Table 8

Fourth Factorial Design Using The STEP Pre-Test

Source Of Variation		dF	Sum Of Squares	Mean Squares	F
Experimental, Control	(1)	1	188.18078	188.18077	20.32914 *
High, Low	(2)	1	4.25532	4.25532	0.45970
Pre, Post	(3)	1	80.52122	80.52121	8.69869 *
Interaction Between	(1,2)	1	10.22337	10.22337	1.10443
Interaction Between	(1,3)	1	0.38306	0.38306	0.04138
Interaction Between	(2,3)	1	0.09574	0.09574	0.01034
Interaction Between	(1,2,3)	1	4.26367	4.26367	0.46060
Within Replicates		368	3406.46729	9.25670	
TOTAL		375	3694.39014		

* Significant At The 0.01 Level

	Pre	Post
○	4.702	5.564
□	6.053	7.043

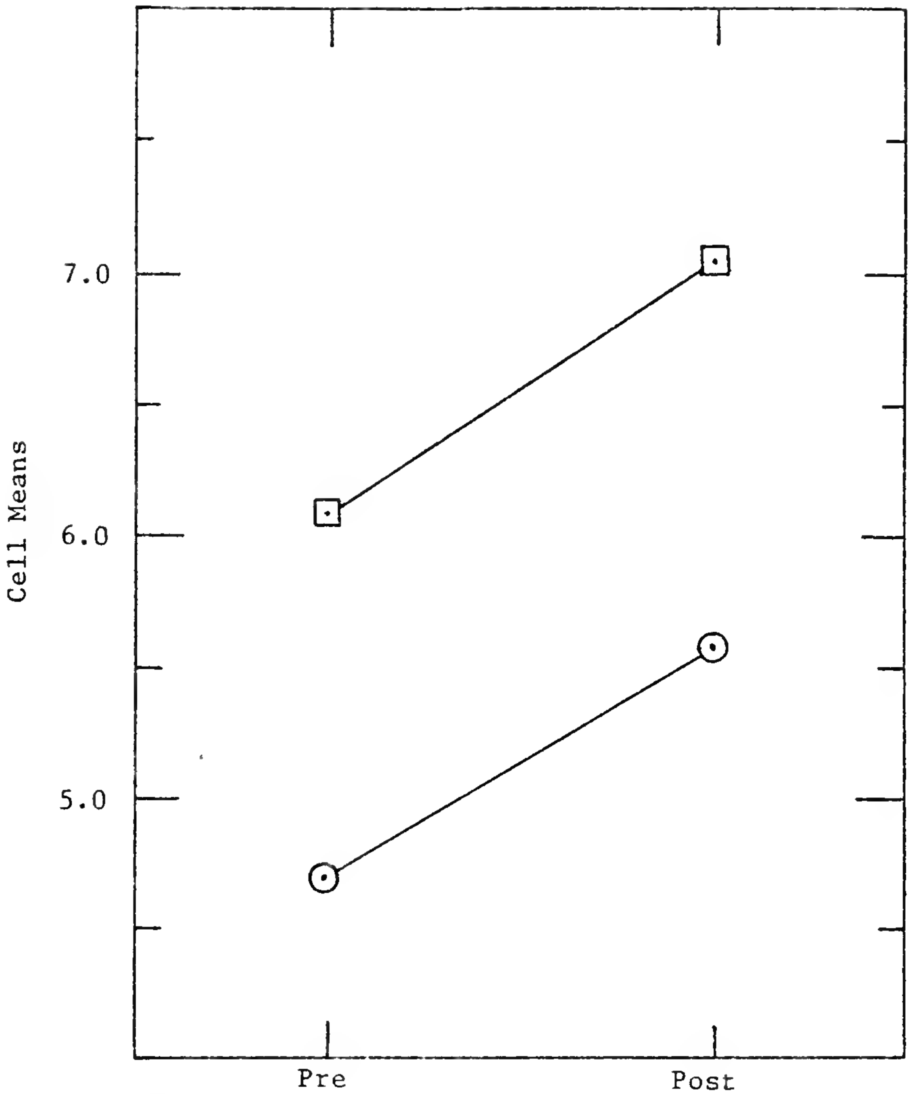

Figure 27: Hypothesis 4:
Interaction Between Variable 1 (Experimental and Control) and Variable 3 (Pre-, Post-test)
○ – Experimental Group, □ – Control Group

	◊	◊
Pre	5.287	5.468
Post	6.181	6.426

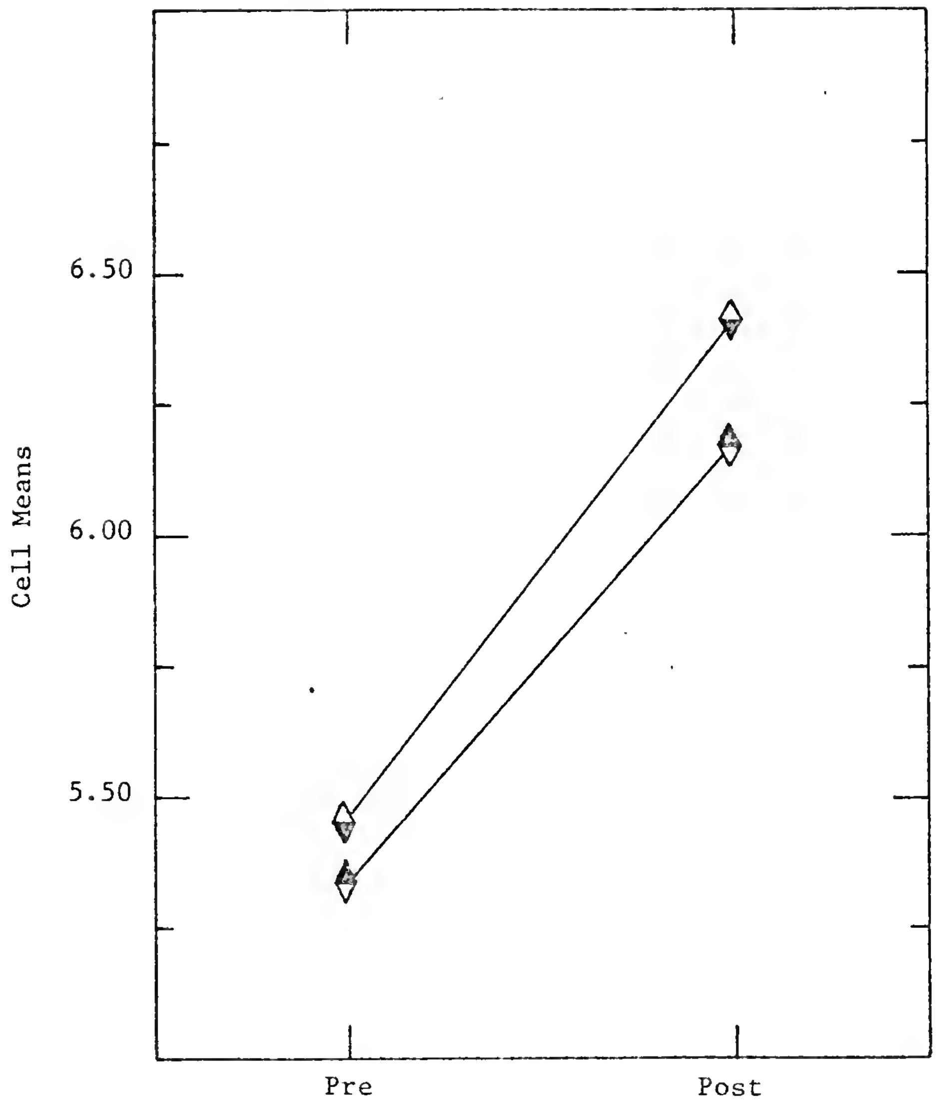

Figure 28: Hypothesis 4:
Interaction Between Variable 2 (High and Low) and Variable 3 (Pre-, Post-test)
◊ - High, ◊ - Low

Pre	4.340	6.234	5.064	5.872
Post	5.383	6.979	5.745	7.106

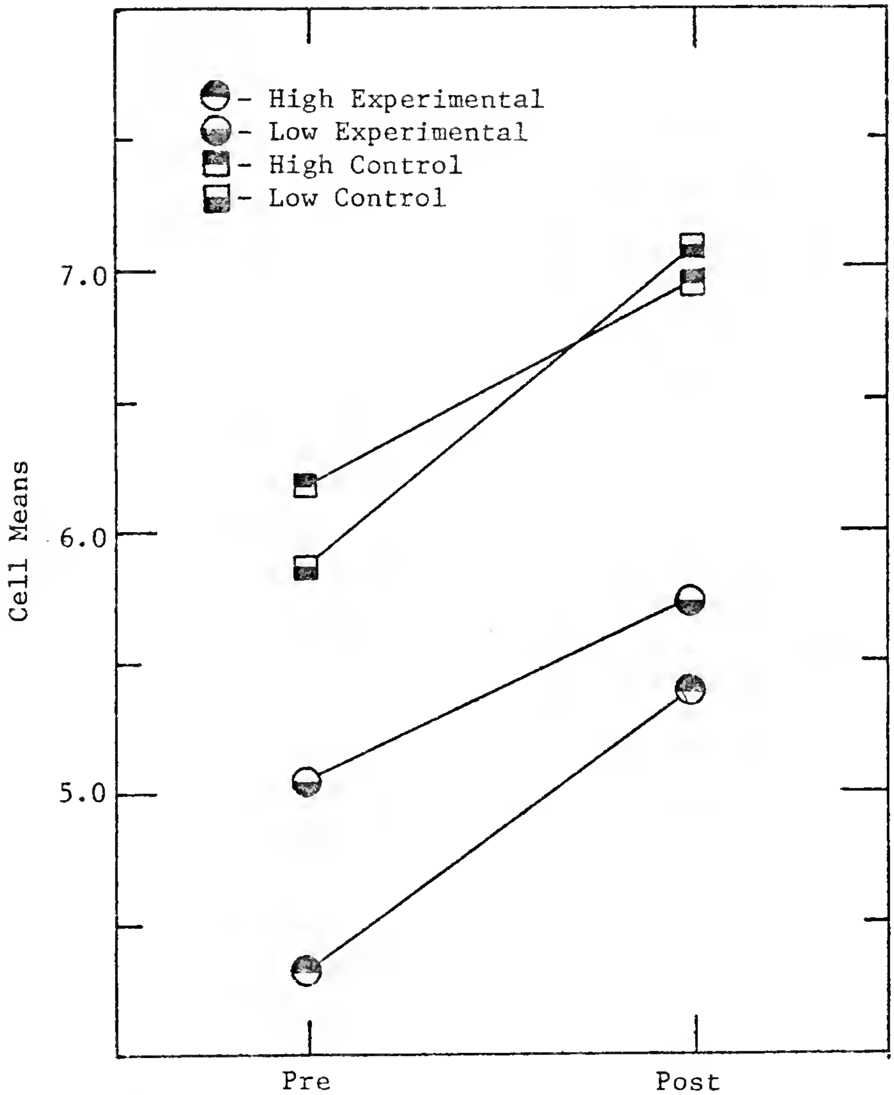

Figure 29: Hypothesis 4: Interaction Between Variable 1 (Experimental and Control), Variable 2 (High and Low) and Variable 3 (Pre-, Post-test)

V. Formative Evaluation

An Individualized Chemistry Student Questionnaire was given to 305 experimental students. A forced-choice scale was used with five choices, number one most positive and number five most negative. Number three was neutral. The questions are all positive response oriented toward the Individualized Chemistry Program. A mean of one would strongly favor the individualized program while a mean of five would indicate a complete disagreement with the program.

The mean for this evaluation was 2.60. The five most favorable questions (≤ 1.9) were:

1. I feel that I can ask questions at any time.
2. Performing experiments in class helps me understand the chemical concepts I have been studying.
3. I ask questions when I don't understand.
4. I chose to take this course.
5. I feel free to discuss chemistry (problems, experiments) with my class mates.

The four questions equal to or greater than 3.2 were:

1. I look back every week (or some other period of time) and evaluate my progress.
2. "Individualized Study" is the best way to study chemistry.
3. I am satisfied with my progress in this class.
4. I plan the work I expect to cover in a week or contracted period of time.

The results of the questionnaire were primarily used to indicate needed changes in the Individualized Chemistry Program. The questionnaire is also a very valuable tool for the teacher to use to better understand the student needs. Figure 30 shows the means for each of the questions.

INDIVIDUALIZED CHEMISTRY QUESTIONNAIRE

PART A

Answer Part A only on the answer sheet provided. For each of the following questions indicate your answer on the answer sheet corresponding to the question number being answered. Use the following scale to code the answer sheet.

1 = Strongly Agree
2 = Agree
3 = Don't Know
4 = Disagree
5 = Strongly Disagree

MEAN = 2.60

This is not a timed test. Take your time and when finished turn in both the questionnaire and the answer sheet to your teacher.

1.73 1. Performing experiments in class helps me understand the chemical concepts I have been studying.

2.13 2. The results of my experiments make sense.

2.20 3. I have enough mathematical background to do the problems assigned.

2.80 4. I see a new value in studying chemistry I did not see before.

2.56 5. The pressure of other classes (having certain assignments ready at certain times) cause me to "put off" doing chemistry.

3.20 6. I am satisfied with my progress in this class.

3.20 7. I plan the work I expect to cover in a week or contracted period of time.

1.66 8. I feel that I can ask questions at any time.

1.80 9. I <u>ask</u> questions when I don't understand.

2.86 10. The tests are fair.

3.56 11. I look back every week (or some other period of time) and evaluate my progress.

2.96 12. I think the tests really measure what I know.

2.50 13. Answering the questions on the guide sheets really helps me.

Figure 30: Student Questionnaire Indicating Question Means

1.83 14. I chose to take this course.

3.23 15. "Individualized Study" is the best way to study chemistry.

2.83 16. I am able to see a direction in what I am studying in chemistry.

2.80 17. I understand and can explain the concepts I have studied in chemistry.

2.53 18. As a result of this course, I now know how some of the great discoveries in science were made.

2.73 19. As a result of this course, I plan to major in science or math in college.

2.83 20. I feel confident that I can handle this subject on an "individual study" basis.

3.16 21. I enjoy discussing this class at home.

1.83 22. I feel free to discuss chemistry (problems, experiments, etc.) with my classmates.

2.43 23. I see relationships between what I am learning in chemistry and what I have learned in other science courses.

2.43 24. I am able to read and understand the textbooks I am using.

1.96 25. From what I have experienced in science, I think a scientist can be creative.

2.86 26. I find science exciting.

Figure 30. (Cont'd.)

VI. Data Analysis And Discussion

The data presented in this chapter do not follow a trend that would normally be expected for this type of study. In order to look carefully at the results, this section will be developed in context with the stated study hypotheses.

Hypothesis one states that there will be no significant difference between the experimental and control groups with respect to achievement in chemistry. This hypothesis was tested using analysis of covariance and was not accepted. Looking at the trend on Figure 13 is somewhat confusing. Why was there a disordinal interaction to such degree in favor of the control group? Figure 20 gives some insight into the problem by indicating a regression with the high group. Figure 21 indicates that the regression possibly is with the experimental group. Figure 22 gives a complete composite view of the interactions. The significance of the data is most likely caused by the disordinal regressive interaction of the high experimental group. The high control group regressed slightly.

A possible explanation is the difference in learning method within the classroom and the fact that the ACS test is designed for students coming from traditional classrooms and not from individualized classrooms.

The Individualized Chemistry Program uses inquiry and discovery techniques in conjunction with many reinforcing laboratory activities in a process oriented method to teach chemistry. Many traditional programs use the "facts only" lecture method of instruction with a few "cookbook" laboratory activities for reinforcement. Since the ACS test is primarily a factual test, the experimental students would probably

have a more difficult time obtaining the correct answers because of lack of training and therefore score lower on the test.

Another possible effect could have been the riots during post-test time. The students were probably more interested in the riots and could care less about the test. If this is a correct assumption, the high group of both the experimental and control group would seem to be more involved in the riots than the medium or low groups.

Another possibility would be that of population mean. Since the medium experimental and low experimental groups start low and end with little net difference between them, the high experimental could have been more careful on the pre-test and scored higher than their group mean. The same could possibly be true with the high control group because of the slight regression. Also note the differences among the high, medium and low post-tests of both the experimental and control groups. They are in a proper sequence for their group which possibly indicates the pre-test was invalid for both high groups.

The second hypothesis states there will be no significant difference between experimental and control groups with respect to reported attitudes toward science. This hypothesis was tested using analysis of covariance and was not accepted.

Figure 14 shows a disordinal interaction with the experimental and control groups. The interaction becomes more distinct on Figure 23 indicating a regression with the high group. Figure 24 shows a net regression for both experimental and control groups. But the experimental group showed a net gain over the control group. This is further clarified with Figure 25. Little net gain with the experimental and control high, medium and low groups occurs. But the regression of the

high group is most likely the cause of the significance. One factor that could be the cause of the regression is the situation of school riots around the post-test times. Also, the high students could possibly not be as successful as they would like and not be positive toward the program. The medium and low groups possibly became more successful during the year and were more positive to the program.

The third hypothesis states there will be no significant difference between experimental and control groups with respect to reading ability. This hypothesis was tested using analysis of covariance and was accepted. Figure 15 shows a slight net gain of the control group. Figure 17 indicates a disordinal interaction of the low group with the medium group. Figure 18 indicates little difference between the experimental and control groups and a greater net gain for the control group. A better understanding of the interactions is shown on Figure 19. The low groups of both the experimental and control groups did measurably better with respect to net gains in reading. This would indicate both the experimental and control schools in the study population are effective in improving the reading ability in the low group.

The fourth hypothesis states that there will be no significant difference between high and low achievers on the STEP Reading Test of either experimental or control groups with respect to achievement in chemistry. This hypothesis was tested using analysis of variance with a factorial design to evaluate the study interactions. From the analysis of the interactions and plots, the hypothesis was accepted.

Figure 27 shows equal net gains for the experimental and control groups indicating a different average mean for each group. Figure 28 shows little net difference between the high and low groups with

respect to achievement in chemistry. Figure 29 indicates little difference in the high and low control groups except for a slight disordinal interaction. This interaction could possibly be due to the large increase in the reading gains for the low control group. From the indicated data, there seems to be little difference in chemistry achievement caused by the difference in reading.

The overall evaluation of the Student Questionnaire indicated a favorable response to the experimental program. It also indicated that:

1. Students feel a need for more pressure to complete their work.

2. Students feel that they could do better if they tried.

3. Students don't think "Individualized Study" is always the best type of program.

This evaluation also provides indications as to where improvements are needed from the student's point of view.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

I. Summary

The problem in this study was to determine the effectiveness of the P. K. Yonge Individualized Chemistry Program in selected public schools in Florida.

The study used a pre-test/post-test control group experimental design using classroom means from classes randomly selected as experimental and control. The study was carried out during a one-year period in twenty-one schools in Florida.

Four types of evaluation were used to determine the effectiveness of the experimental program. They were:

1. the ACS Chemistry Test,
2. the STEP Reading Test,
3. the All-School-Subject Attitude Test,
4. a Student Questionnaire for formative analysis of the experimental program.

All these evaluations except the questionnaire were administered both pre and post to the study classes. Each test had two equivalent forms eliminating testing as a cause of invalidity.

The data analysis was done on an IBM-370 computer at the University of Florida using the Biomedical Statistical Programs. Data analysis indicated the following results:

1. A significant difference at the 10 percent level was found between the experimental and control groups with respect to achievement in chemistry in favor of the control group. The major source of the difference was found to be in the high experimental group which had a considerable regression in achievement in chemistry. The reasons for this regression are possibly the test and the difference in population test means.

2. A significant difference at the 10 percent level was found between the experimental and control groups with respect to attitude toward chemistry in favor of the experimental group. Little overall interaction was shown but a net overall gain was seen in the experimental group.

3. No difference was found between the experimental and control groups with respect to reading ability.

4. There was no difference found between high and low achievers on the STEP Reading Test of either experimental or control groups with respect to achievement in chemistry.

5. Evaluation of the Student Questionnaire indicated a favorable attitude toward the Individualized Chemistry Program. Also, indications of problem areas were pointed out.

II. Conclusions

The following conclusions seem to be supported by the findings from this study:

1. The control group showed a significantly greater gain on the ACS test.

2. Achievement in reading is not related to achievement in chemistry as measured on the ACS test.

3. The experimental group had significantly less regression in attitude toward science during the year than the control group.

4. Students in the Individualized Chemistry Program indicated a positive feeling for the program. They also found the Individualized Chemistry Program consistant with process oriented chemistry programs.

III. Limitations

While the above conclusions appear to logically follow from the data, certain limitations should be kept in mind:

1. The ACS achievement test was not designed for an individualized type of program. It was designed for the traditional type chemistry class.

2. All evaluations were administered by teachers. During post-testing, many schools had problems with integration and had riots throughout the post-testing period. This most likely had an effect on post-testing and is probably reflected in both the achievement in chemistry and attitude evaluations.

3. The data primarily used for the study were class means for most of the evaluations. Random selection of the study population was done by classes, not students. Some of the data used were individual students. These data were used for the trend interaction analysis and should be considered with caution because of the population not being randomly selected.

IV. Recommendations

The Individualized Chemistry Program, as seen in this study, is a functional program in chemistry and is as successful as most traditional programs in chemistry for Florida schools. This study has raised many questions as to the future of individualized programs in chemistry. The data from this study clearly indicates the need for more studies in this area. The following are suggestions for future research in individualized chemistry:

1. Random selection of students rather than classes would allow the researcher a greater freedom in the study by providing a larger population and fewer limitations.

2. The development and evaluation of an achievement test to measure the achievement in chemistry of a student in an individualized program in chemistry would provide the researcher with more positive knowledge of the trend in the students' achievement. The instrument should be designed to be consistant with the individualized program.

3. A content analysis of materials taught in both the Individualized Chemistry Program and the traditional chemistry courses would allow the researcher to incorporate 'content' weighting factors into the course comparisons.

4. A study involving a test on reading speed and on comprehension and a valid achievement test in chemistry would allow the researcher to better determine interrelations among these areas of student ability.

5. A study of the effectiveness of the Individualized Chemistry Program versus the traditional chemistry program with educationally disadvantaged students would allow the researcher to analyze from a different perspective the effectiveness of the individualized type course. Also this would provide research data for comparative analysis of the average student versus the disadvantaged student in an individualized type course as opposed to the traditional type course.

6. A study of the student-teacher interactions in the classroom would allow the researcher to determine how effective the individualized program personalizes and meets the needs of the students. This data could be compared to similar data obtained from a traditional chemistry classroom.

V. Remarks

The development of the Individualized Chemistry Program was an attempt to personalize instruction in an abstract science subject such as chemistry. The development, implementation and evaluation of the program brought forth many problems with the technique of individualization. The first was the definition of individualization which was discussed earlier in this study. The next problem was the preparation of the students for an individualized program. Since most students have never been allowed to progress at their own rate, how could one expect a group of students thrown into an individualized class to individualize? They could not be expected to do much more than become frustrated. Hopefully this program would not allow this problem to occur because of the initial self-pacing in the program.

But the greatest problem confronting the individualized program was the teacher. Individualization requires more work than traditional teaching but many teachers think it requires less work. This is evident after the first few weeks of class as the teacher starts becoming frustrated because the students began asking too many questions.

All these problems and many others are present because individualization is a new thing to our educational system and not well understood. This is most likely the reason so many individualized programs are unsuccessful.

This study was done to see if an individualized program could be taught successfully and if not, why. One of the whys for this study is teacher training. This researcher believes that for any individualized program to be successful, the teacher has to be trained in the individualized technique. The future of successful individualization in the classroom is going to depend on the universities making available the proper training in the field and in the academic classroom to prepare a teacher to be a competent and effective resource person in an individualized classroom.

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BIOGRAPHICAL SKETCH

Paul Anthony Becht was born December 9, 1941 in Detroit, Michigan. In June 1959, he was graduated from Trinity High School, Louisville, Kentucky. He was a recipient of the Michael Lanahan Foundation Scholarship during his studies at the University of Louisville from which he received his B.A. degree in June 1964, his major field being chemistry with minors in engineering, physics and mathematics. He received his M.Ed. degree from the University of Florida in June 1968, his major field being science education with a minor in physics.

From 1961 through 1962 he worked as an assistant electronic engineer at Wright Patterson Air Force Base, Dayton, Ohio. From 1962 through 1964, he worked as an assistant histopathologist at St. Joseph's Infirmary, Louisville, Kentucky. From 1964 through 1967 he served as a member of the Peace Corps and taught science and engineering sciences at St. Elizabeth Technical High School, Jamaica, West Indies. He worked as an electronics technician in the Department of Nuclear Engineering from 1967 through spring of 1968 and as a teaching assistant in the Department of Physics during the spring and summer of 1968 at the University of Florida. From 1968 through 1970 he was a research assistant in the College of Education and taught as a part-time science instructor at P. K. Yonge Laboratory School at the University of Florida. From 1970 to present he has been employed as a science instructor at P. K. Yonge Laboratory School, University of Florida.

He has developed a program for underachieving science students which was used in the West Indies from 1968 through 1969; and in 1970 he implemented, pilot tested and field tested an individualized program in chemistry for high schools which was used in Florida high schools from 1970 to present and has been used in other high schools throughout the nation. He conducted a National Science Foundation Short Course for Individualized Chemistry including a follow-up study from June 1973 to June 1974. He conducted a pilot study on the Aviology Program, a physics course using aviation as a motivator, which he developed, from 1972 to 1973. It was funded by the Federal Aviation Administration and the Florida Department Of Transportation. He has developed an Aviology Concept Program which is currently undergoing pilot study in several Florida high schools. He has assisted in the development of materials for the Physics 10 Program at P. K. Yonge which is currently undergoing pilot study in Florida high schools.

He has served as chairman of the session on verbal behavior at the National Association For Research In Science Teaching 45th annual meeting, April 1972; as chairman of session on aviation education at the National Science Teachers Association annual meeting, April 1973; as chairman of the board of directors of the Bingham Environmental Education Foundation, University of Florida, from 1973 to present; as chairman of the Aviation Advisory Committee, Santa Fe Community College, Gainesville, Florida from 1972 to present; and as a member of the Aviation Advisory Committee, Lake City Community College, Lake City, Florida.

His publications include a publication in Science Education on a summer institute for junior high physics teachers, Research Monograph (No. 4) at P. K. Yonge on the Individualized Chemistry Program, a Florida Educational Research and Development Council research bulletin on the individualization of instruction, and the report on his Aviology Program to the Florida Department Of Transportation which was published by the Federal Aviation Administration. His Individualized Chemistry Program materials will be published by Omni Print, Inc.

He has presented numerous papers in his field at regional and national meetings of professional societies.

He is a member of Phi Delta Kappa, American Association for Advancement of Science, National Science Teachers Association, National Association for Research in Science Teaching, American Chemical Society, American Association of Physics Teachers, American Institute of Physics, International Oceanographic Foundation, National Aerospace Education Association, Civil Air Patrol (Education Associate), and the Florida Association of Aerospace Educators.

He is also an amateur radio operator (general class), a certified SCUBA diver, and a private pilot.

He is married to the former Sara-Maria Francis Deese, and has a son, Sean Vincent, and a daughter, Laura Christina.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Vynce A. Hines

Vynce A. Hines, Chairman
Professor of Education

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Richard E. Garrett

Richard E. Garrett
Professor of Physics and Astronomy

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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